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TWO-COLOUR PHOTOMETRIC STUDIES OF THE ECLIPSING BINARY SYSTEMS TW DRACONIS, Z HERCULIS AND RS VULPECULAE

BY

R. L. BAGLOW

1952
TORONTO, CANADA

TWO-COLOUR PHOTOMETRIC STUDIES OF THE ECLIPSING BINARY SYSTEMS TW DRACONIS, Z HERCULIS AND RS VULPECULAE

By R. L. Baglow

Summary.

The observations on which this study is based were obtained in 1950 and 1951. Part of the observations were made at the David Dunlap Observatory, but the greater part were made at the Steward Observatory of the University of Arizona.

The three eclipsing variables, TW Draconis, Z Herculis and RS Vulpeculae, were chosen for observation in the hope that the circumstances of the eclipses might prove favourable for the estimation of the limb darkening of the components by showing annular, or deep total, eclipses. The system TW Drac shows a deep total eclipse at primary minimum, and it is possible to derive an estimate of the limb darkening in two colours from a reduction of the observations in the primary minimum by the method of least squares. This variable has been previously studied by R. H. Baker,[1] who reported an asymmetric light curve. I find the asymmetry to be much smaller than reported by Baker.

Nijland's visual observations of the system Z Herc were interpreted by Fetlaar[2] as being due to an annular eclipse. I find, however, a partial eclipse, and the solution is too indeterminate to allow a determination of the limb darkening effect. It is possible to estimate the difference in the degree of limb darkening in two colours.

The system RS Vulp has been studied by Baker[3] and by Dugan[4]. Baker found an annular eclipse at primary minimum, Dugan a partial. The present study agrees with Dugan's. Again the uncertainties in the solution of a system exhibiting a partial eclipse do not allow a determination of the limb darkening, but an estimate can be made of the differential limb darkening.

Corrections to the times of minima predicted from the ephemerides were found to be necessary in all three systems. The reason for the departure of the systems TW Drac and Z Herc from the ephemeris is not clear. A small correction to the period of RS Vulp is suggested.

A study of the colour of the reflection effect shows that in each system the colour of the reflected light is the same as the colour of the brighter component.

The measurements of the ellipticity effect are not sufficiently exact to allow conclusions to be drawn about the photometric behaviour of the distorted components.

1. *Observational Material—General.*

The measurements in this study were made with the aid of the photoelectric photometers of the David Dunlap Observatory and of the Steward Observatory, Tucson, Ariz. (April-June 1951). Experiments in photoelectric photometry using the 1P21 photomultiplier were begun at the David Dunlap Observatory late in 1948, and have continued. At present the measuring instrument is a null-indicating D.C. amplifier mounted on a 19-inch telescope. The photometer used at the Steward Observatory is mounted on a 36-inch telescope and uses a light chopper with an A.C. amplifier.

Atmospheric conditions were mostly much better at Tucson, where the bulk of the observations were made, than at Toronto. Pettit has made an extensive study of the transmission of the atmosphere at Tucson. On some few nights measurements were made through dust, haze or broken cloud. In general the transparency was good. The comparison stars were chosen to be as like the variables in colour, and as close in position, as possible. Corrections for differential extinction are believed to be negligible in comparison with observational scatter. There was no convenient constant light source for determining the changes in the transmission of the atmosphere. The measurements were made in two colours of effective wave-lengths 4370A. and 5100A. A group of four comparisons in the two colours took 20 to 30 minutes to complete, and the resulting normal point of observation is thought to have a probable error of between $0^m.005$ and $0^m.010$.

2. *Observational Material—TW Draconis.*

The system TW Drac was observed on 32 nights. Approximately 400 measures were made which were averaged into some 130 normal points. The normal points are tabulated by phase in the appendix. The comparison star used was H.D. 140512, R.A. (1900) 15 h. 38 m., Dec. (1900) 62° 11′, A5; the variable is H.D. 139319, R.A. (1900) 15 h. 32 m., Dec. (1900), 64° 14′, A6 and G2.

Primary minimum seems quite symmetrical. The harmonic analysis of the observations outside eclipse shows a small asymmetry which appears to be real, but may be the result of a bad distribution of observations, or intrinsic variability of one of the components of the eclipsing system. The eclipsing system TW Drac has a small visual companion, about 3 seconds of arc away. The measures of the system include the light of the visual companion. The light of the visual companion was measured independently; it proved difficult and only on a few nights was the seeing sufficiently steady to allow the two components to be observed independently. Nineteen measurements were made on three nights and the brightness of the companion star to the system TW Drac was found to be 0.051 in both colours, the light unit being the luminosity of the companion star H.D. 140512. This amount was subtracted from the observations before analysis.

Plots of the observations are shown in figures 1 and 2. Secondary minimum appears to be later than the half-period by $0^d.010$ to $0^d.020$. The observed epoch of primary minimum was 1951 June 1.128, J.D. 2433798.628.

3. Observational Material—Z Herculis.

The system Z Herc was observed on 26 nights. Approximately 400 measures were made which were averaged into 95 normal points shown in the appendix. A plot of the observations is given in figures 3 and 4. The comparison stars used were H.D. 164043, R.A. (1900) 17 h. 54.2 m., Dec. (1900) 14° 52′, F8; and H.D. 162705 R.A. (1900) 17 h. 47.3 m, Dec. (1900) 15° 01′, F0. The variable is H.D. 163950, R.A. (1900) 17 h. 53.6 m., Dec. (1900) 15° 09′, F2 and F5.

The estimated epoch of primary minimum was 1951 June 3.503, J.D. 2433801.003.

4. Observational Material—RS Vulpeculae.

The system RS Vulp was observed on 31 nights. Approximately 500 measures were made, which were averaged into some 130 normal points, shown in the appendix. Plots of the observations are shown in figures 5 and 6. The comparison stars used were H.D. 180889, R.A. (1900) 19 h. 13.2 m., Dec. (1900) 21° 38′, A3; and H.D. 180811, R. A. (1900) 19 h. 12.9 m., Dec. (1900) 22° 15′, B9. The variable is H.D. 180939, R.A. (1900) 19 h. 13.4 m., Dec. (1900) 22° 16′, B8 and A5.

Primary minimum is well covered, but unfortunately it proved impossible to cover the ascending branch of secondary minimum. Secondary minimum occurs later than the half-period by $0^d.030$ to $0^d.040$. The epoch of primary minimum from these observations was 1951 June 4.787, J.D. 2433802.287.

5. Analysis of Observations—TW Draconis.

Harmonic analysis of observations outside eclipse yielded

$$\underset{(\pm\, 0.001\text{ m.e.})}{L = 2.012} \quad \underset{(\pm\, 0.001\text{ m.e.})}{- 0.0198 \cos\theta} \quad \underset{(\pm\, 0.005\text{ m.e.})}{- 0.0613 \cos^2\theta} \quad \underset{(\pm\, 0.001\text{ m.e.})}{+ 0.0172 \sin\theta,}$$

in the yellow, and

$$\underset{(\pm\, 0.001\text{ m.e.})}{L = 1.887} \quad \underset{(\pm\, 0.001\text{ m.e.})}{- 0.0191 \cos\theta} \quad \underset{(\pm\, 0.005\text{ m.e.})}{- 0.0635 \cos^2\theta} \quad \underset{(\pm\, 0.001\text{ m.e.})}{+ 0.0098 \cos\theta.}$$

in the blue.

A preliminary graphical study led to an estimate of k about 0.76 to 0.78 and the coefficient of limb darkening in the two colours about

0.6. As the observations seemed to justify a more careful study the measures were grouped into normal points and rectified as shown in Table I.

TABLE I

OBSERVATIONS CORRECTED FOR LIGHT OF VISUAL COMPANION, AND GROUPED INTO NORMAL POINTS, TW DRACONIS

Phase degrees	L (obs.) (yellow)	Refl. Light	L	Ellipt. Effect	L (rect.)	Corr.
29.200	0.9469	4	0.9465	0.9726	0.9731	− 9
25.692	0.8949	3	0.8946	0.9707	0.9216	− 27
23.800	0.8368	3	0.8365	0.9698	0.8625	− 32
20.846	0.7572	2	0.7570	0.9687	0.7814	− 32
17.456	0.6394	2	0.6392	0.9672	0.6608	− 3
15.166	0.5548	1	0.5547	0.9664	0.5738	+ 32
13.170	0.4691	1	0.4690	0.9660	0.4856	+ 48
11.800	0.4207	1	0.4206	0.9656	0.4355	+ 55
10.367	0.3610	1	0.3609	0.9653	0.3739	+ 56
8.716	0.2976			0.9650	0.3083	+ 52
7.945	0.2712			0.9647	0.2811	+ 50
7.172	0.2429			0.9645	0.2518	+ 45
6.663	0.2262			0.9644	0.2345	+ 41
6.060	0.2106			0.9644	0.2183	+ 37
5.436	0.1960			0.9643	0.2032	+ 31
5.004	0.1930			0.9642	0.2001	+ 25
4.486	0.1800			0.9642	0.1866	+ 20
3.888	0.1733			0.9640	0.1797	+ 5
0.000	0.1687			0.9640	0.1750	0
	(Blue)					
29.227	0.9569	4	0.9565	0.9772	0.9788	− 9
25.637	0.8927	3	0.8924	0.9757	0.9146	− 30
23.696	0.8442	3	0.8439	0.9749	0.8656	− 35
21.200	0.7815	2	0.7813	0.9738	0.8823	− 38
17.403	0.6154	2	0.6152	0.9727	0.6324	0
15.030	0.5147	1	0.5146	0.9721	0.5293	+ 41
13.572	0.4477	1	0.4476	0.9716	0.4606	+ 53
12.080	0.3790	1	0.3789	0.9713	0.3900	+ 57
10.927	0.3313	1	0.3312	0.9710	0.3410	+ 59
9.352	0.2731			0.9707	0.2813	+ 57
8.109	0.2198			0.9706	0.2264	+ 51
,6.851	0.1775			0.9705	0.1828	+ 43
6.000	0.1560			0.9704	0.1607	+ 37
5.646	0.1476			0.9703	0.1521	+ 34
5.186	0.1345			0.9703	0.1386	+ 29
4.658	0.1278			0.9702	0.1317	+ 19
4.037	0.1154			0.9702	0.1189	+ 10
0.000	0.1094			0.9700	0.1127	0

The observations of a portion of the primary minimum made on May 12 show an interesting deviation from those made on the same portion of the light curve on May 15 and June 12. The measures

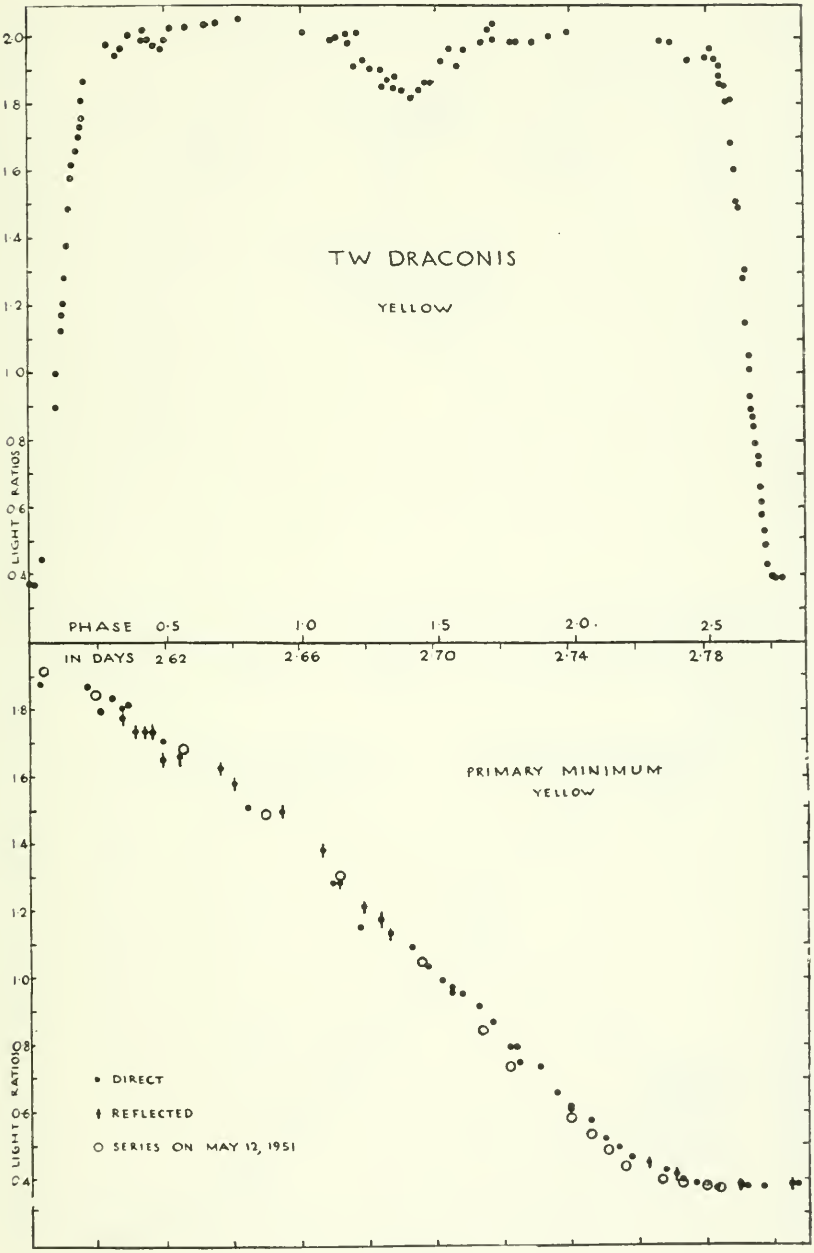

TW DRACONIS
YELLOW
LIGHT RATIOS
PHASE 0·5 1·0 1·5 2·0 2·5
IN DAYS 2·62 2·66 2·70 2·74 2·78
PRIMARY MINIMUM
YELLOW
LIGHT RATIOS
• DIRECT
REFLECTED
O SERIES ON MAY 12, 1951

FIG. 1

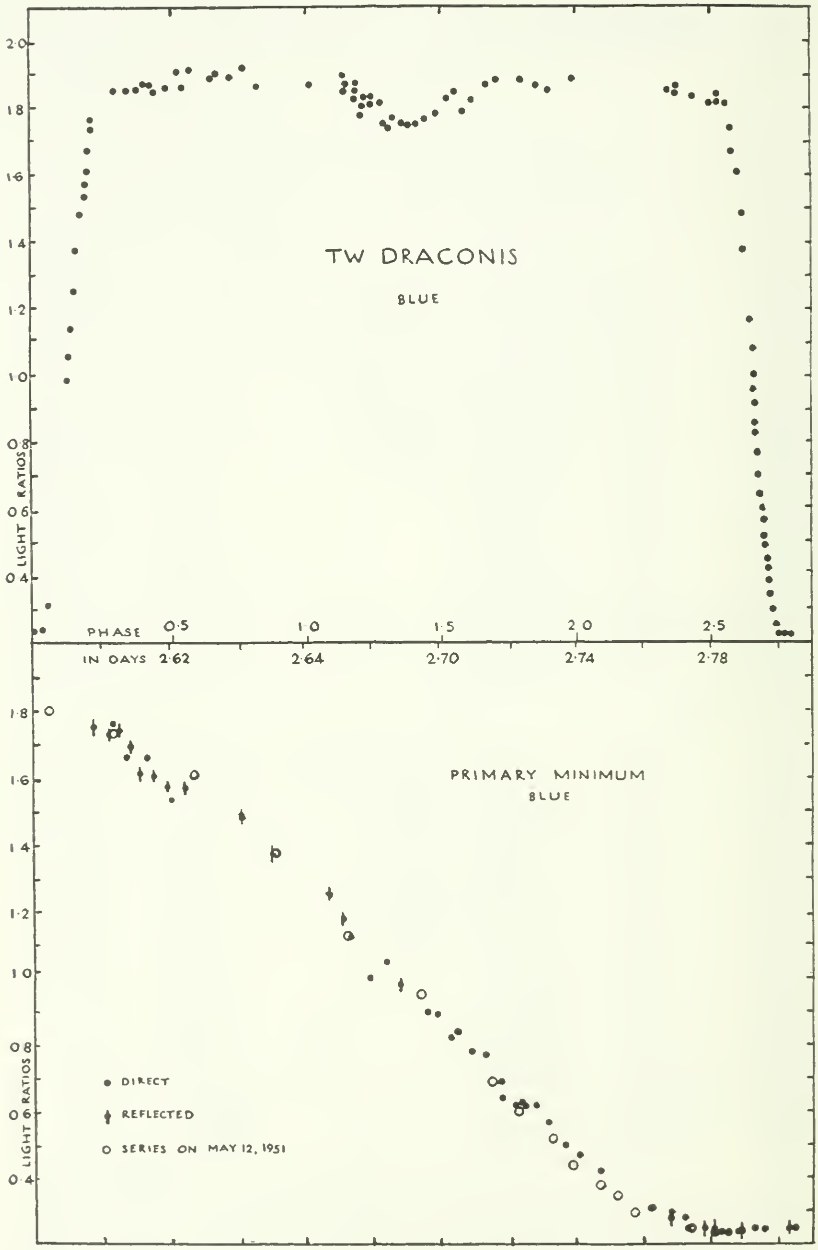

TW DRACONIS
BLUE
LIGHT RATIOS
PHASE
IN DAYS
0·5
1·0
1·5
2·0
2·5
2·62
2·64
2·70
2·74
2·78
PRIMARY MINIMUM
BLUE
DIRECT
REFLECTED
SERIES ON MAY 12, 1951

Fig. 2

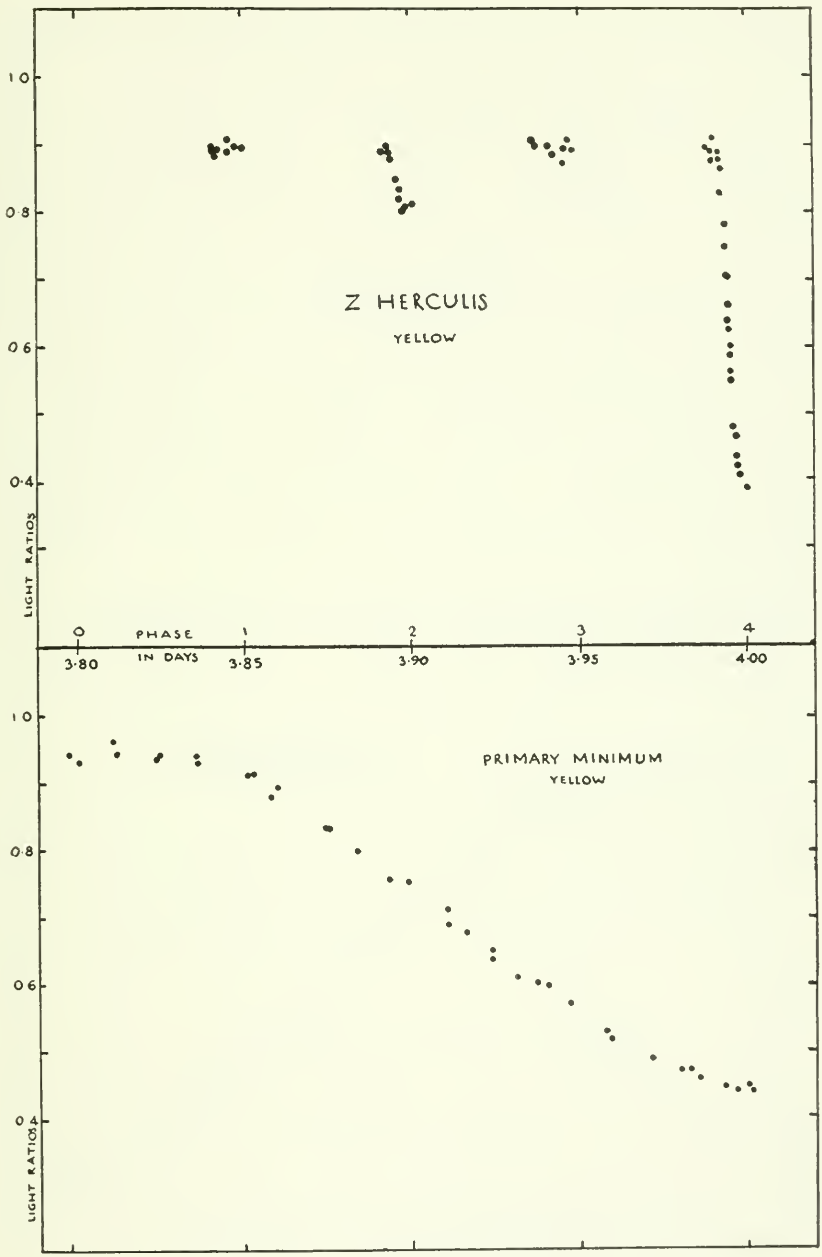
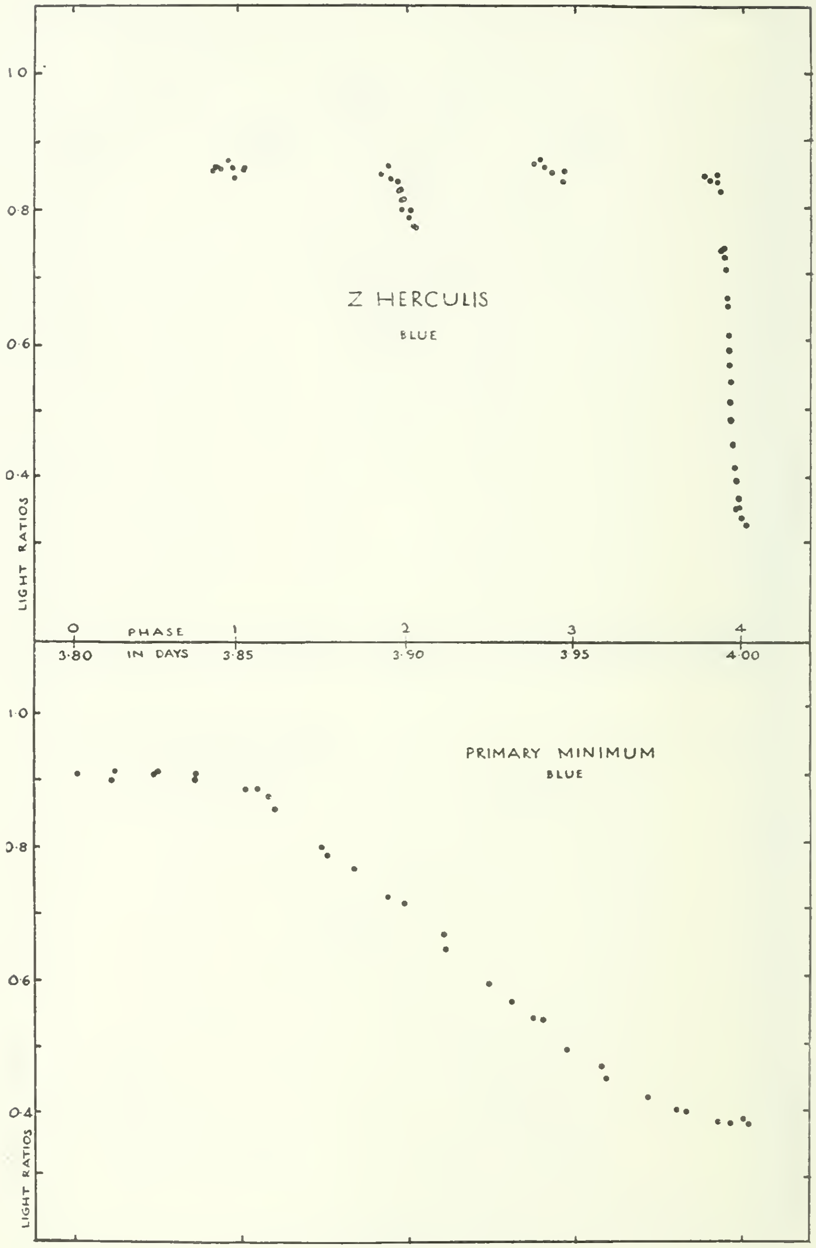

Z HERCULIS
YELLOW
LIGHT RATIOS
1·0
0·8
0·6
0·4
PHASE
IN DAYS
0
1
2
3
4
3·80
3·85
3·90
3·95
4·00
PRIMARY MINIMUM
YELLOW

Fig. 3



LIGHT RATIOS
1.0
0.8
0.6
0.4
Z HERCULIS
BLUE
0
PHASE
1
2
3
4
3.80
IN DAYS
3.85
3.90
3.95
4.00
PRIMARY MINIMUM
BLUE

FIG. 4

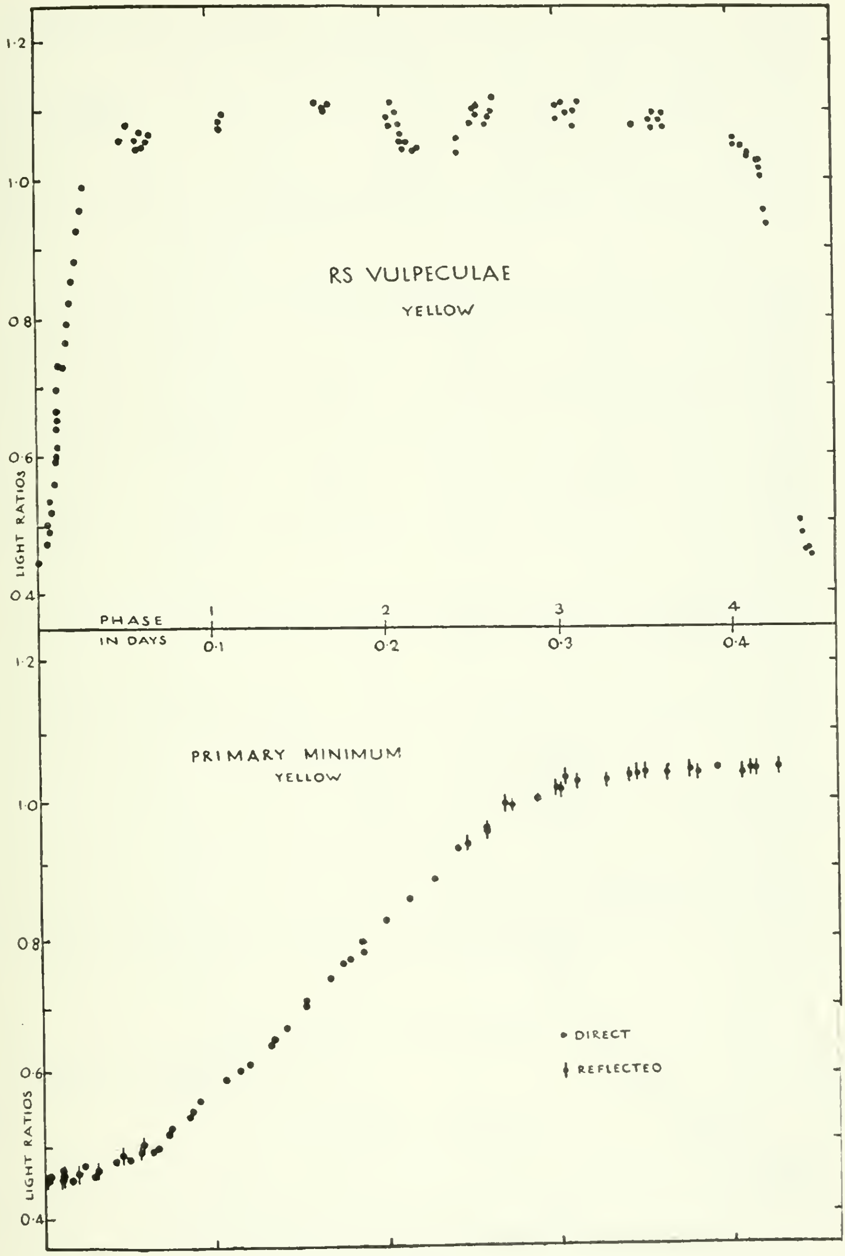

RS VULPECULAE
YELLOW
PRIMARY MINIMUM
YELLOW
LIGHT RATIOS
PHASE
IN DAYS
0·1
0·2
0·3
0·4
1
2
3
4
1·2
1·0
0·8
0·6
0·4
• DIRECT
REFLECTED

FIG. 5

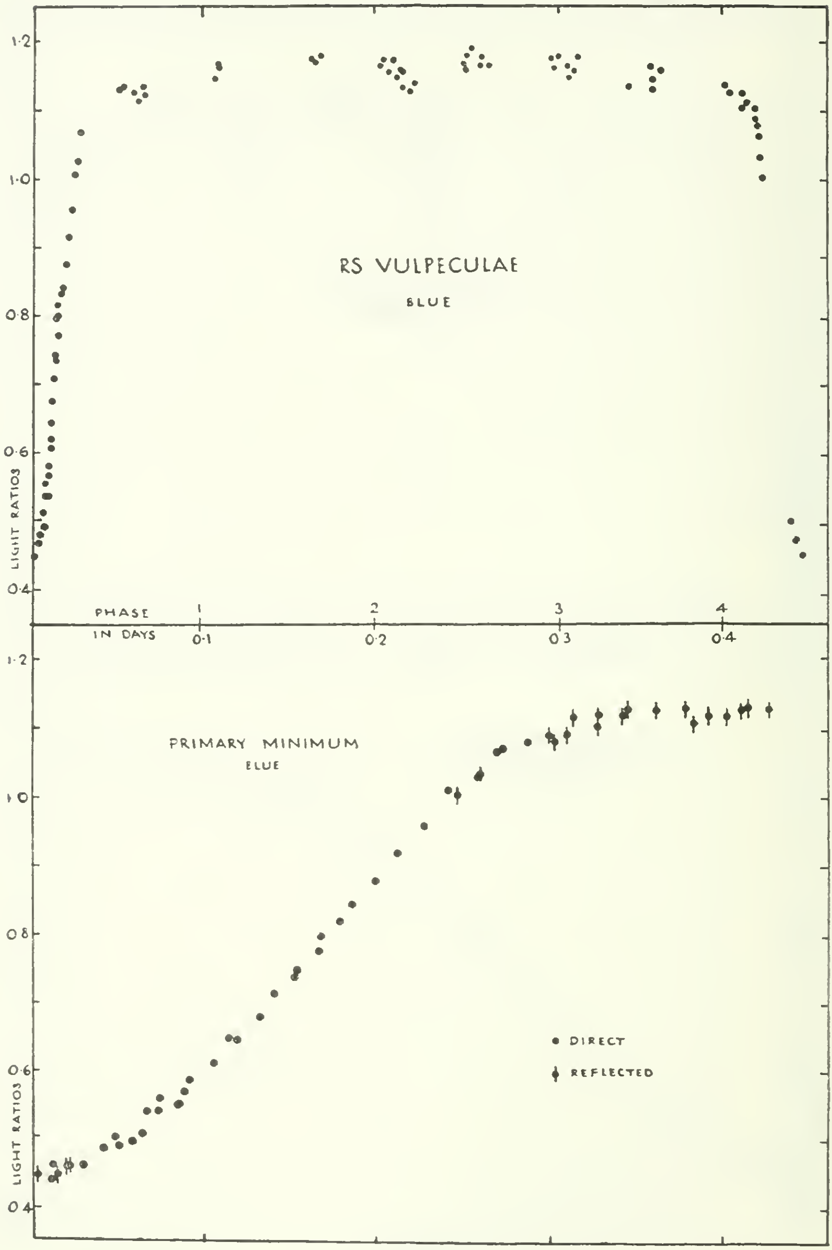

RS VULPECULAE
BLUE
PRIMARY MINIMUM
BLUE
LIGHT RATIOS
PHASE
IN DAYS
1
2
3
4
0·1
0·2
0·3
0·4
1·2
1·0
0·8
0·6
0·4
DIRECT
REFLECTED

FIG. 6

made on May 12 began by falling among the measures made on other nights, but quite suddenly began to fall below the other measures by 0.02 to 0.03 light units until totality neared, when the differences diminished. The disagreement of the observations of May 12 with those of May 15 and June 12 disappeared at the onset of totality. It is believed that this variation is a real phenomenon. It is not known what cause could operate to block off 2 to 3 per cent. of the light of the brighter component of the system. Similar observations have been reported by Kron.[5]

The preliminary elements were corrected by the method of least squares, using the tables of Tsesevitsch[6] and Irwin[7]. The corrections to the preliminary elements were rather large, and the process had to be repeated. The reduction was made with the observations of primary minimum only. The secondary minimum is shallow, annular and afflicted with the reflection effect. The uncertainties of the process of "rectification" were thought to be large. The reduction was made in the two colours simultaneously. This requires some justification. The preliminary graphical analysis did not show any large difference in the elements derived from the two light curves independently. After the least-squares reduction the residuals of computed from observed points showed a similar trend in each light curve. This would not be the case if there was a significant difference in the geometric elements defined by the two colours. It is believed that the determination of the elements is considerably strengthened by making the reduction in the two colours simultaneously.

The fainter component of the system TW Drac is considerably distorted. The distortion was estimated using Pierce's estimate of the mass ratio quoted by Wood[8]. An attempt was made to correct for the effect of the distorted form of the faint component following methods suggested by Kopal.[9] Following Kopal, if we write for the error within the minima of the spherical model,

$$L = -L_1[(1-x)h^u + xh^d],$$

then I have used

$$h^u = \frac{1}{k^2}(V_1 - V_2)I_1{}^0{}_{,0}$$

$$\frac{2}{3}h^d = \frac{1}{k^2}(V_1 - V_2)I_1{}^0{}_{,1}\left(\frac{\delta}{r_2}\right)^{\frac{1}{2}},$$

where V_1 and V_2 are the rotational distortions of the bright and faint components respectively. I find the additional terms suggested by Kopal are sufficiently small to be neglected.

The α-function corrected for "perturbations" is shown in Table II.

TABLE II

α-FUNCTIONS, TW DRACONIS

Phase degrees	Yellow α (corr.)	α (uncorr.)	Phase degrees	Blue α (corr.)	α (uncorr.)
29.200	0.0336	0.0326	29.227	0.0249	0.0239
25.692	0.0983	0.0950	25.637	0.0996	0.0962
23.800	0.1705	0.1667	23.696	0.1554	0.1515
20.846	0.2688	0.2650	21.200	0.2270	0.2228
17.456	0.4115	0.4111	17.403	0.4142	0.4143
15.166	0.5126	0.5165	15.030	0.5258	0.5305
13.170	0.6176	0.6235	13.572	0.6019	0.6079
11.800	0.6775	0.6842	12.080	0.6810	0.6875
10.367	0.7515	0.7589	10.927	0.7360	0.7427
8.716	0.8321	0.8384	9.352	0.8035	0.8100
7.945	0.8653	0.8714	8.109	0.8661	0.8718
7.172	0.9014	0.9069	6.851	0.9161	0.9210
6.663	0.9229	0.9279	6.000	0.9417	0.9459
6.060	0.9430	0.9475	5.646	0.9517	0.9556
5.436	0.9620	0.9658	5.186	0.9675	0.9708
5.004	0.9665	0.9696	4.658	0.9764	0.9786
4.486	0.9835	0.9859	4.037	0.9918	0.9930
3.888	0.9936	0.9943			

These values of the α-function are to be compared with the values in the tables for a spherical model darkened to the limb according to the usual law. In order to see what was the effect of allowing for the distortion by Kopal's methods, the least-squares reduction was made twice, once on the α-function derived from the observations allowing for the perturbations, and once on the directly observed α-function. The elements derived in the two ways hardly differ significantly. The corrections for the effect of distortion, estimated from the preliminary elements are not quite right, but since their effect is barely significant it was not thought worth-while recomputing them.

The starting point for the final least-squares correction was $r_2 = 0.3020$, $r_1 = 0.2143$, $k = .71$, x(yellow) $= 0.2$, x(blue) $= 0.3$. With these parameters the p-function was calculated for the phase of each of the normal points of observation. The α-function was computed from the tables of Tsesevitsch[6], and the residuals were used to form a number of equations of observation for computing corrections to the parameters with the aid of Irwin's tables[7] of differential coefficients. The normal points were weighted according to the number of observations included. The observations of the deeper part of the eclipse were also given greater weight, since the accuracy of the observations gets better during the deeper part of the eclipse.

The values of the parameters resulting from the solution which takes account of Kopal's correction terms, together with the estimated probable error of the determination, were

$r_2 = 0.3064 \pm 0.0002$; $r_1 = 0.2118 \pm 0.0010$; $\cos^2 i = 0.0059 \pm 0.0005$; x(yellow) $= 0.11 \pm 0.12$; x(blue) $= 0.27 \pm 0.11$.

The solution obtained by ignoring Kopal's corrections gives the same geometrical elements, but the estimates of the limb darkening are altered to x(yellow) = 0.25, and x(blue) = 0.37. According to either solution the difference in the degree of limb darkening between the two colours is 0.15, and this difference should have good precision, since it is free from many of the systematic sources of error which make the determination of the absolute value of the limb darkening so difficult.

TABLE III

Residuals of Computed from Observed Values of the α-function Resulting from the Least-squares Corrections, TW Draconis

Comp.	Obs.	Resid.	Comp.	Obs.	Resid.
0.0199	0.0336	+0.0137	0.0182	0.0249	+0.0067
0.1002	0.0983	−0.0019	0.0997	0.0996	−0.0001
0.1599	0.1705	+0.0106	0.1527	0.1554	+0.0027
0.2711	0.2688	−0.0023	0.2537	0.2270	−0.0267
0.4187	0.4115	−0.0072	0.4236	0.4142	−0.0094
0.5194	0.5176	−0.0018	0.5532	0.5258	−0.0274
0.6215	0.6176	−0.0039	0.6081	0.6019	−0.0062
0.6808	0.6775	−0.0033	0.6822	0.6810	−0.0012
0.7557	0.7515	−0.0042	0.7370	0.7360	−0.0010
0.8315	0.8321	+0.0006	0.8104	0.8035	−0.0069
0.8641	0.8653	+0.0012	0.8647	0.8661	+0.0014
0.8955	0.9014	+0.0059	0.9135	0.9158	+0.0023
0.9156	0.9229	+0.0073	0.9416	0.9417	+0.0010
0.9382	0.9430	+0.0058	0.9517	0.9517	0.0000
0.9588	0.9620	+0.0032	0.9651	0.9675	+0.0024
0.9749	0.9665	−0.0079	0.9782	0.9764	−0.0018
0.9871	0.9835	−0.0036	0.9918	0.9918	0.0000
0.9965	0.9936	−0.0029			

The residuals show a marked systematic trend. The reason for this is unknown. It may arise from a systematic error in the method of reduction, for example in the process of rectification, or a systematic error in the analysis, for example in the assumption of linear darkening to the limb, or it may be the effect of one or two individual observations with large residuals.

Accepting Pierce's estimate of the mass ratio as 3.6 we find the relative orbit comes out to be 11.6×10^6 km. The dimensions of the components are 3.53 and 5.10 times the sun in radius, the surface gravities, 0.480 and 0.060, the mean densities 0.130 and 0.012 for the bright and faint components respectively, all in terms of the sun. The residuals of the computed α-function from the observed are shown in Table III.

6. Analysis of Observations—Z Herculis.

The season of 1951 promised to be unusually favourable for observing this difficult system. Unfortunately the minima were found to be occurring later than predicted by the ephemeris and it appeared doubtful whether or not the phase of conjunction was reached. The analysis of the observations based on the shape of the light curve strongly suggests that conjunction occurred between predicted phases 4.00d. and 4.01d. Although it would be a good deal more comforting to have rounded the minimum, I do not think that the estimated time of conjunction is out by more than 10 minutes. I accept the observation of earlier workers that the duration of the total phase, if any, is less than 0.015d. In combination with the shape of the light curve, this rules out the possibility of a total eclipse at primary minimum.

A few spectrographic observations in 1949 and 1951 seem to show the velocity of centre of mass greater than found by Adams and Joy[10] by 10 km./sec. If these observations are correct they may show a third body motion of the system, but further spectrographic observations will be needed to establish this point.

For photometric measures only the one comparison star H.D. 164043 was used. The two comparison stars were intercompared on 14 occasions. There was no significant evidence of variability of the comparison stars.

Harmonic analysis of the observations outside eclipse yielded

$$L = 0.893 - 0.0028 \cos\theta - 0.0089 \cos^2\theta$$
$$(\pm 0.001) \quad (\pm 0.001) \quad (\pm 0.005)$$

in the yellow, and

$$L = 0.851 - 0.0049 \cos\theta + 0.0060 \cos^2\theta$$
$$(\pm 0.001) \quad (\pm 0.001) \quad (\pm 0.005)$$

in the blue.

Normal points of observation were read off a smooth curve and the observations "rectified" for ellipticity in the usual way, giving the loss of light, as a function of predicted phase, shown in Table IV.

TABLE IV

Rectification, Z Herculis

Phase days	Rect. Lum. (yellow)	Loss of Light	Rect. Lum. (blue)	Loss of Light
3.83	1.010	0.010	1.002	0.002
3.84	0.983	0.017	0.990	0.010
3.85	0.969	0.031	0.974	0.026
3.86	0.930	0.070	0.934	0.066
3.87	0.895	0.105	0.884	0.116
3.88	0.851	0.149	0.845	0.155
3.89	0.810	0.190	0.802	0.198
3.90	0.770	0.230	0.755	0.245
3.91	0.726	0.274	0.707	0.293
3.92	0.684	0.316	0.653	0.347
3.93	0.643	0.357	0.610	0.390
3.94	0.601	0.399	0.557	0.443
3.95	0.557	0.443	0.510	0.490
3.96	0.520	0.480	0.469	0.531
3.97	0.494	0.506	0.439	0.561
3.98	0.469	0.531	0.412	0.588
3.99	0.446	0.554	0.397	0.603
4.00	0.440	0.560	0.388	0.612
4.01	0.431	0.569	0.380	0.620
1.83	1.006		1.010	
1.85	1.006		1.010	
1.87	1.000		1.003	
1.89	0.982		0.994	
1.91	0.964		0.980	
1.93	0.942		0.961	
1.95	0.924		0.941	
1.97	0.910		0.928	
1.99	0.906		0.922	
2.01	0.902		0.922	

The phases are the predicted phases from the elements given in Kukarkin and Parenago, "Catalogue of Variable Stars". The predicted time of primary minimum is at phase 3.993 d. The estimated time of primary minimum occured at about phase 4.01 d.

The observations cannot be well represented as an annular eclipse, or as a partial transit. The representation as a partial occultation is good, with a rather wide range of the parameters. The ratio of the radii, $k = 0.6$ or $k = 0.7$ gives a good representation, but k cannot be as small as 0.5, and is probably not as large as 0.8. Various trials were made of the assumed phase of conjunction from predicted phase 4.00d. to predicted phase 4.030d., but the best representation is obtained by taking conjunctions as occurring at predicted phase 4.010d.

The estimates of L_1 and L_2 were obtained by a comparison of the relative depths of the two minima at corresponding points,

$$
\begin{array}{llll}
k = 0.6 & L_1 = 0.666 & L_2 = 0.334 & \text{(yellow)} \\
 & L_1 = 0.720 & L_2 = 0.220 & \text{(blue)} \\
k = 0.7 & L_1 = 0.723 & L_2 = 0.277 & \text{(yellow)} \\
 & L_1 = 0.783 & L_2 = 0.217 & \text{(blue)}
\end{array}
$$

These estimates give the values of the α-function shown in Table V.

TABLE V

α-FUNCTIONS, Z HERCULIS

Phase days	$k = 0.6$			$k = 0.7$		
	α (yell.)	α (blue)	$\Delta\alpha$	α (yell.)	α (blue)	$\Delta\alpha$
3.84	0.025	0.014	− 11	0.024	0.013	− 11
3.85	0.046	0.036	− 10	0.043	0.033	− 10
3.86	0.105	0.091	− 14	0.097	0.084	− 13
3.87	0.158	0.157	− 1	0.145	0.144	− 1
3.88	0.223	0.215	− 8	0.206	0.197	− 9
3.89	0.285	0.275	− 10	0.263	0.253	− 10
3.90	0.345	0.340	− 5	0.318	0.313	− 5
3.91	0.411	0.407	− 4	0.379	0.374	− 5
3.92	0.474	0.481	+ 7	0.437	0.443	+ 6
3.93	0.536	0.541	+ 5	0.493	0.497	+ 4
3.94	0.598	0.614	+ 16	0.551	0.566	+ 15
3.95	0.665	0.680	+ 15	0.613	0.625	+ 12
3.96	0.720	0.736	+ 16	0.664	0.676	+ 12
3.97	0.760	0.778	+ 18	0.699	0.716	+ 17
3.98	0.808	0.815	+ 7	0.745	0.751	+ 6
3.99	0.831	0.836	+ 5	0.765	0.770	+ 5
4.00	0.849	0.849	+ 9	0.773	0.781	+ 7
4.01	0.854	0.860	+ 6	0.785	0.791	+ 6

The systematic run of the differences in the α-functions is attributed to differential limb darkening. The run of $\Delta\alpha$, with the run of differences to be expected theoretically, is shown in figure 7. When the difference in the degree of limb darkening is estimated by a method suggested by Irwin[7] there results $\delta x = 0.22$ for $k = 0.6$ or 0.7. This estimate depends systematically on the assumptions made in the analysis, and is perhaps uncertain by $\pm$ 0.1.

The elements derived by assuming the limb darkening 0.4 in the yellow are

$$
\begin{aligned}
i &= 83^\circ - 84^\circ, \\
r_1 &= 0.11 - 0.13 \odot, \\
r_2 &= 0.19 - 0.18 \odot.
\end{aligned}
$$

Taking the dimensions of the relative orbit as 10.5×10^6 km., there result

radii of components	1.8 $\odot$ and 2.8 $\odot$,
surface gravities	0.46 $\odot$ and 0.18 $\odot$,
mean densities	0.26 $\odot$ and 0.06 $\odot$,

for the brighter and fainter components respectively.

7. Analysis of Observations—RS Vulpeculae.

The phases predicted from the elements given in *Rocznik Astronomiczny*, No. 22, were corrected by 0.007d. An examination of the residuals of computed from observed phases for the last thirty years suggests strongly that the currently accepted period is a little too long. I suggest that better elements would be epoch J.D. 2420606.623, period 4.477660d.

The two comparison stars were intercompared on 36 occasions. There was no significant evidence of variability. During the deep eclipse the fainter comparison star was used, at other times the brighter comparison star.

Harmonic analysis of the observations outside eclipse yielded

$$L = \underset{(\pm 0.001 \text{ m.e.})}{1.1576} - \underset{(\pm 0.001 \text{ m.e.})}{0.031 \cos \theta} - \underset{(\pm 0.003 \text{ m.e.})}{0.016 \cos^2 \theta} + \underset{(\pm 0.001 \text{ m.e.})}{0.0006 \sin \theta},$$

in the blue, and

$$L = \underset{\pm 0.001 \text{ m.e.}}{1.0876} - \underset{\pm 0.001 \text{ m.e.}}{0.0346 \cos \theta} - \underset{\pm 0.003 \text{ m.e.}}{0.0226 \cos^2 \theta} + \underset{\pm 0.001 \text{ m.e.}}{0.0033 \sin \theta},$$

in the yellow. The units are those of the brighter comparison star.

For analysis the observations were plotted on a large scale and normal points were read off a smooth curve at intervals of 2 degrees in phase. The primary minimum was "rectified" by subtracting the contribution of the reflected light as estimated from the harmonic analysis outside eclipse. The "rectification" of ellipticity was carried out by division in the usual way. This gave the values for the loss of light, as a function of phase, shown in Table VI.

This analysis of the system RS Vulp is considerably weakened by the scant observations of the secondary minimum. The best estimate of the depth of secondary minimum, rectified for ellipticity, is 0.044 in the blue and 0.058 in the yellow, with an estimated uncertainty of 0.005.

The amount of light reflected at full phase is 0.054 in the blue and 0.063 in the yellow, so that if our estimate of the depth of the secondary minimum is correct the secondary minimum cannot be a

TABLE VI

RECTIFICATION, RS VULPECULAE

Phase	L (Yellow)	Refl. Light	*L*	Ellipt. Effect	*L* (Rect.)	1-*L*
0°	0.448	0.0000	0.448	1.034	0.433	0.567
2	0.451		0.451		0.436	0.564
4	0.475		0.475		0.459	0.541
6	0.517		0.517		0.500	0.500
8	0.578		0.578		0.559	0.441
10	0.630	0.0005	0.629	1.034	0.609	0.391
12	0.695	0.0008	0.694	1.035	0.671	0.329
14	0.760	0.0010	0.759		0.734	0.266
16	0.825	0.0013	0.824	1.035	0.796	0.204
18	0.883	0.0017	0.881	1.036	0.850	0.150
20	0.943	0.0021	0.941	1.036	0.908	0.092
22	0.992	0.0025	0.990	1.037	0.954	0.046
24	1.015	0.0030	1.012	1.037	0.976	0.024
	(Blue)					
0	0.448	0.0000	0.448	1.109	0.404	0.596
2	0.457		0.457		0.412	0.588
4	0.485		0.485		0.437	0.563
6	0.532		0.532		0.479	0.521
8	0.586		0.586		0.530	0.470
10	0.655	0.0005	0.654	1.109	0.590	0.410
12	0.732	0.0007	0.731	1.110	0.658	0.342
14	0.805	0.0009	0.804		0.724	0.276
16	0.877	0.0012	0.876	1.110	0.789	0.211
18	0.952	0.0015	0.951	1.111	0.856	0.144
20	1.015	0.0019	1.013		0.912	0.088
22	1.060	0.0023	1.066	1.111	0.959	0.041
24	1.090	0.0027	1.087	1.112	0.978	0.022

total eclipse. This is in agreement with the conclusion reached by Dugan[4].

On the hypothesis of a partial eclipse the observed secondary minimum is partly due to the eclipse of the reflected light and partly due to the eclipse of the intrinsic light of the faint component. I have made separate estimates of the contribution of each to the secondary minimum, assuming the reflected light is completely darkened to the limb, the intrinsic light partially. Comparison of the depths of the two minima then give estimates of the luminosity of each component for assumed values of k ranging from 0.6 to 0.9. These estimates of the luminosity were used to calculate the α-function during primary eclipse, and the hypothesis was tested by methods due to Kopal.[9]

I find the observations of RS Vulp are not well satisfied by the hypothesis of a transit at primary minimum. They were well satisfied by the hypothesis of an occultation at primary minimum with

k 0.7 or 0.8. The true value of k may be somewhat smaller than 0.7, but cannot be as small as 0.6, and is probably not as large as 0.9.

The estimates of α_0, L_1 and L_2 for the various assumed values of k were,

k	α_0	L_1	L_2	
0.6	0.677	0.837	0.163	yellow
	0.684	0.872	0.128	blue
0.7	0.648	0.876	0.124	yellow
	0.655	0.911	0.089	blue
0.8	0.622	0.912	0.108	yellow
	0.636	0.937	0.063	blue
0.9	0.601	0.932	0.068	yellow
	0.620	0.953	0.047	blue

For the values of $k = 0.7$ and $k = 0.8$ these lead to the values of the α-function shown in Table VII. The difference of the α-functions

TABLE VII

α-FUNCTIONS, RS VULPECULAE

Phase degrees	$k = 0.7$			$k = 0.8$		
	α (yell.)	α (blue)	$\Delta\alpha$	α (yell.)	α (blue)	$\Delta\alpha$
0	0.648	0.655	+ 8	0.621	0.636	+ 15
2	0.644	0.646	+ 2	0.618	0.628	+ 10
4	0.618	0.619	+ 1	0.595	0.601	+ 6
6	0.565	0.571	+ 6	0.548	0.556	+ 8
8	0.503	0.516	+ 13	0.483	0.502	+ 19
10	0.447	0.451	+ 4	0.429	0.437	+ 8
12	0.375	0.376	+ 1	0.361	0.365	+ 4
14	0.304	0.303	− 1	0.292	0.295	+ 3
16	0.233	0.232	− 1	0.224	0.225	+ 1
18	0.171	0.158	− 13	0.165	0.154	− 11
20	0.105	0.096	− 9	0.101	0.094	− 7
22	0.052	0.045	− 7	0.050	0.043	− 7
24	0.027	0.024	− 3	0.026	0.023	− 3

for the two colours is attributed to the difference in limb darkening. Evaluating $\Delta\alpha$ by a method suggested by Irwin[7] the best estimate is

$$x = 0.18 \text{ for } k \text{ assumed} = 0.7,$$
$$x = 0.27 \text{ for } k \text{ assumed} = 0.8.$$

The values depend systematically on the assumption about the depths of the minima, and may be uncertain by about $\pm$ 0.1.

The geometrical elements are derived assuming $x = 0.4$ in the yellow, then

$$i = 78°,$$
$$r_1 = 0.19 - 0.21,$$
$$r_2 = 0.28 - 0.26.$$

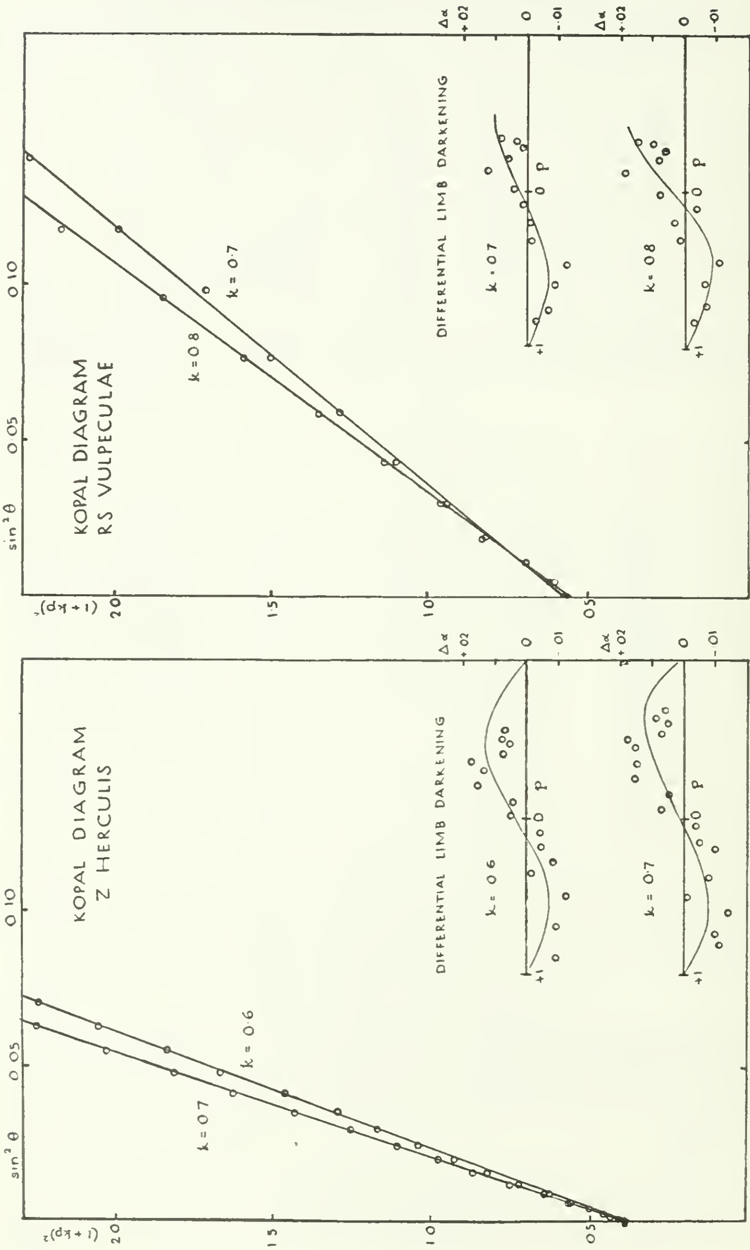

KOPAL DIAGRAM
RS VULPECULAE
KOPAL DIAGRAM
Z HERCULIS
DIFFERENTIAL LIMB DARKENING
DIFFERENTIAL LIMB DARKENING
k = 0·7
k = 0·8
k = 0·6
k = 0·7
sin² θ
(1 + kp)²
Δα

Fig. 7

Taking the dimensions of the relative orbit as about 14.5×10^6 km., these result in

radii of components	4.2 ⊙ and	5.6 ⊙,
surface gravities	0.25 ⊙ and	0.045 ⊙,
mean densities	0.06 ⊙ and	0.008 ⊙,

for the brighter and fainter components respectively.

8. Discussion.

It is a valuable feature of the systems TW Drac, Z Herc and RS Vulp that we have spectrographic observation of the spectral types and of the masses of their components. These are of varying weights. The spectral types of the components of TW Drac and Z Herc are well determined, the spectral type of the faint component of RS Vulp is more uncertain. The masses of the components of Z Herc[10] and RS Vulp[11] are well determined, those of TW Drac are probably quite uncertain, and for it I use an estimate by Pierce, quoted by Wood.[8] The dimensions and densities of the components derived with the aid of the spectrographic data are quoted above. Except for the system Z Herc, the components seem to lie pretty well on the main sequence.

A simple photometric datum which can be compared with the spectrographic data is the colour index of the components of these systems. I am obliged to Prof. E. F. Carpenter for making available to me his measures of the colour indices of a number of stars of known spectral type, as observed with the Tucson photometer. The luminosities of the components are given in terms of the light of the comparison star as unit. The observed colour index of the comparison star (reduced to the zenith) can be used to calculate the colour index of the components. This colour index can be used to give an estimate of the spectral type based on Carpenter's data, and the result can be compared with the spectral type determined by the aid of the spectrograph. The results are as follows:

	C.I.	Est. Sp.	Obs. Sp.
TW Drac	− 0.20	A5	A6
	+ 0.47	K5	K2
RS Vulp	− 0.40	G	A2
	+ 0.0	F	F2
Z Herc	+ 0.04	F	F2
	+ 0.4	G-K	F5

The agreement seems reasonable except for the system Z Herc.

Another way of comparing the photometric and spectrographic data is to estimate the difference in spectral type by comparing the observed depths of minima, which are approximately in the ratio of the surface brightness of the components. The estimate is crude since it is based on the black body assumption and an assumed temperature scale which may not be valid. Russell[12] has given a table by means of which such an estimate may be made. I have used the rectified depths of minima, but have corrected them as carefully as possible for the reflected light, so that the ratios represent the undisturbed disks as nearly as possible.

The data used were:

	Depths of Min.	Log Ratio	Sp. from Russell's Table
TW Drac	0.825, 0.078	1.02	A6 and M
	0.887, 0.048	1.27	A6 and later than M
RS Vulp	0.566, 0.04	1.2	B5 and A2
	0.596, 0.03	1.3	B5 and A5
Z Herc	0.569, 0.10	0.75	F and K
	0.620, 0.08	0.84	F and later than M

The agreement seems fair for the systems TW Drac and RS Vulp. The latter system has been considered to be anomalous in this respect but my measures do not indicate very much of an anomaly. The discrepancy between the estimates of spectral type and the observed spectral type of the system Z Herc is very great, however, and it is difficult to see how the cool star can have a spectrum of type F.

Another comparison can be made with the spectroscopic data by comparing the determination of the difference in magnitude of the components of the systems RS Vulp and Z Herc which have been found spectrophotometrically by Petrie,[13] with those found in this study. Petrie finds for the system RS Vulp, Δm 3.4 $\pm$ 0.9 while I find Δm to be 2.7 to 2.9 (in the blue). The agreement seems reasonable. For the system Z Herc, however, there is a considerable discrepancy between his estimate of Δm 0.4 $\pm$ .06 and mine of Δm 1.1 to 1.4.

Another simple datum to be derived from the photometric measurements is the colour index of the reflected light. As the reflection effect is small this colour index is not very precise, but it is of interest to calculate it and compare it with the observed colour index of the components of the system. I find the colour index of the reflected light in these systems to be

	C.I. of Refl. Light
TW Drac	− 0.2,
RS Vulp	− 0.1,
Z Herc	− 0.6.

Not much weight can be attached to the measured colour for the system Z Herc as the coefficients are so small. The colour of the reflected light of the system TW Drac is the same as the colour of the brighter component. This is contrary to Milne-Eddington theory of the reflection effect. A similar observation has been made by Walter[14] on the system ζ Aurigae. The reflection effect in the system RS Vulp shows a similar tendency but the effect is smaller. The colour of the reflected light of the system is different from the colour of the fainter component, whether we consider the observed colour of the inner hemisphere (facing the brighter component) or the outer hemisphere. It does not seem, therefore, that the discrepancy can be explained by allowing for the higher temperature of the inner hemisphere. These data suggest that whatever the processes producing the reflection effect are, they are more complicated than the simple picture of absorption followed by re-emission at a lower temperature.

The calculations based on the Milne formulae give the right order of magnitude for the reflection effect except in the case of TW Drac. The computed reflection effect and the observed reflection effect for the three systems are

		Computed	Observed	
TW Drac	yellow	0.029	0.010	
	blue	0.032	0.010	
RS Vulp	yellow	0.027	0.031	$k = 0.7$
	blue	0.028	0.027	
	yellow	0.023	0.031	$k = 0.8$
	blue	0.024	0.027	
Z Herc	yellow	0.008	0.005	$k = 0.6$
	blue	0.009	0.006	
	yellow	0.007	0.005	$k = 0.7$
	blue	0.008	0.006	

The comparison of the observed ellipticity effect with the theoretical ellipticity effect is subject to considerable uncertainties arising from the uncertain contribution of the reflection effect to the second harmonic, and uncertainty about the spectral type of the faint component, and its darkening to the limb. Accepting the mass ratios for the systems which have been given from spectrographic evidence, I find the oblateness of the components due to tidal distortion to be

	Bright Component	Faint Component
TW Drac	0.004	0.150
RS Vulp	0.003 – 0.004	0.106 – 0.085
Z Herc	0.001 – 0.003	0.012 – 0.010

If the disks of the stars were uniformly bright the observed ellipticity effect would be the mean of these oblatenesses (weighted according to the luminosities of the components) multiplied by $\sin^2 i$. The observed effect may be greater by as much as a factor of 1.6 if the disks are completely darkened to the limb.

The weighted means of the oblatenesses for these systems are:

	Yellow	Blue	
TW Drac	0.027	0.020	
RS Vulp	0.016	0.012	$k = 0.7$
	0.013	0.009	$k = 0.8$
Z Herc	0.005	0.004	$k = 0.6$ or 0.7

Before a comparison can be made the observed effect must be increased by an amount estimated from the reflection effect. This amount must be considered to be rather uncertain in any case, and particularly for the system TW Drac, for which the theory does not seem to give a very good estimation of the reflection effect.

The observed ellipticity effect together with the estimated corrections from the reflection effect which are to be added to it are:

		Observed Effect	Reflection Effect	Sum
TW Drac	yellow	0.031	0.013	0.044
	blue	0.032	0.013	0.045
RS Vulp	yellow	0.014	0.011	0.025
	blue	0.020	0.011	0.031
Z Herc	yellow	0.010	0.004	0.014
	blue	0.007	0.004	0.011

The data are pretty uncertain but there seems to be an indication that there is an additional factor besides the ordinary limb darkening contributing to the observed ellipticity effect. It is not possible to estimate the magnitude of this factor. Even this conclusion would have to be altered if we have overestimated the contribution of the reflected light to the second harmonic variation.

It remains to compare the observed limb darkening effects with the theoretical effects. This effect was best observed in the system TW Drac in which the differential limb darkening is quite accurately determined, and certain limits placed on its absolute value, namely, that it is probably equal to 0.3 or less for wave-length 5100 A., and 0.5 or less for wave-length 4370 A. These determinations are to be compared with certain data calculated by Chandrasekhar and Münch[15] on the basis of a model in which the continuous absorption is due to the negative hydrogen ion, and to neutral hydrogen. The data given show that for a given spectral type the limb darkening coefficient is very nearly a linear function of the wave-length, at least in the visible region. The values they suggest for an A5 star are 0.77 for wave-length 4570A. and 0.65 for wave-length 5100A. But they remark that the linear approximation for the darkening to the limb is not very good for the visual region. Accordingly, the theoretical coefficient ought to be reduced somewhat. By considering a hypothetical eclipse of a star like the Chandrasekhar-Münch model I estimate the correction to the theoretical coefficient can hardly be greater than 0.1.

Actually the observed values of the limb darkening for A stars are smaller than the theoretical values by amounts of 0.2 and more. It happens that estimates of the limb darkening have been made for three A stars as shown here:

		Obs. Coeff.	Theor. Coeff.
TW Drac	4370A.	0.22 ± 0.12	0.77
	5100A.	0.11 ± 0.11	0.65
YZ Cass[16]	4500A.	0.40 ± 0.04	0.73
	6700A.	0.33 ± 0.03	0.44
AR Cass[17]	4500A.	0.0 ± 0.04	0.73

These measurements strongly suggest that in the visual region, at least, the observed coefficients of limb darkening are considerably smaller than the approximate theory would lead us to expect. It also appears that there are real differences in the degree of limb darkening of stars of the same spectral class.

As the limb darkening is a nearly linear function of the wave-length the expression of the difference of the degree of limb darkening in different wave-lengths as a gradient is strongly suggested. It is the nature of the analysis of eclipsing variables that the difference in the degree of limb darkening can be measured with much more reliability than the absolute amount of limb darkening, since many of the systematic uncertainties in the determination of the absolute amount of limb darkening cancel out when we form the gradient. Thus we have for the gradient (difference in limb darkening coefficient divided by difference in wave-length in thousands of Angstroms).

	Observed	Theoretical
TW Drac	0.15	0.15
YZ Cass	0.07	0.13
Z Herc	0.2 ± 0.1	0.12
RS Vulp	0.2 ± 0.1	0.12?

The gradients for TW Drac, RS Vulp and Z Herc are derived from this study. The gradient for YZ Cass is derived from Kron's measures. Strictly speaking the gradient derived from Kron's measures will be slightly affected by the fact that he reduced his measures in the two colours independently, and there is a small difference in the radii he finds for the stars in reducing the light curves in the two colours. The difference is probably not real, and a better estimate of the gradient would be obtained by forcing the geometrical elements to be the same in each colour. The effect would probably be to increase the gradient of the limb darkening estimated from the observations. The theoretical estimate of the gradient for the B5 star of the system RS Vulp is only rough as it is derived from an interpolation between the value Miss Underhill[18] gives for an O9.5 star, and the values given by Chandrasekhar and Münch for an A star.

It seems from these data that the wave-length dependence of the limb darkening coefficient is well represented by current theories.

This brief study is perhaps sufficient to show that accuracy of observation is now sufficiently good to allow us to obtain data on the limb darkening effect in a variety of systems. At the least, observations in two colours will allow a determination of the differential limb darkening effect, if systems showing a well-defined total phase are chosen. There are a number of systems which offer some hope of determining the absolute value of the limb darkening coefficient, among them TX Cass, VV Orio, TT Auri, CP Orio and TW Andr.

Some of these are systems in which two spectra are observed. Observations of a number of such systems offer hope of clearing up some of the uncertainties about the reflection and ellipticity effects. A better understanding of these effects would go far towards removing the existing systematic uncertainties in the analysis of the light curves of eclipsing binaries.

The writer desires to express his gratitude to Prof. E. F. Carpenter of the Steward Observatory for the generous facilities he provided, and to colleagues at the David Dunlap Observatory for steady support and encouragement. He is much indebted to the late Prof. F. S. Hogg, who initiated the construction of a photometer at the David Dunlap Observatory.

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References

1. Baker, *Laws Obs. Bull Coll.* vol. 33, 1921.
2. Fetlaar, *Rec. Ast. Utrecht*, vol. 9, part I, 1923.
3. Baker, *Laws Obs. Bull.* vol. 32, 1921.
4. Dugan, *Princ. Cont.* vol. 6, 1924.
5. Kron, *P.A.S.P.* vol. 59, p. 261, 1947.
6. Tsesevitsch, *Bull. Astr. Inst. of the U.S.S.R. Acad. Sci.* No. 45, 1939, and No. 50, 1940.
7. Irwin, *Ap. J.* vol. 106, p. 380, 1947.
8. Wood, *Ap. J.* vol. 112, p. 199, 1950.
9. Kopal, *Harv. Mon.* No. 8, p. 141.
10. Adams and Joy, *Ap. J.* vol. 49, p. 192, 1919.
11. Stilwell, *R.A.S.C., Jour.*. vol. 40, p. 144, 1946.
12. Russell, *Ap. J.*, vol. 104, p. 153, 1946.
13. Petrie, *D. A. O., Pub.*, vol. XVIII, No. 10, 1950.
14. Walter, *Z. f. Ap.*, vol. 14, p. 62, 1937.
15. Chandrasekhar and Münch, *Harv. Circ.*, No. 453, 1949.
16. Kron, *Ap. J.* vol. 96, p. 173, 1942.
17. Kopal, *Proc. Amer. Phil. Soc.*, vol. 36, p. 350, 1943.
18. Underhill, *K. Danske Vidensk. Selsk. Mat.-fys. Medd.*, vol. 25 No. 13, 1950.

Richmond Hill, Ontario
May 28, 1952

APPENDIX

Normal Points of Observation for TW Draconis
Heliocentric phase from epoch 2433032.351 Julian Date
Period 2,8067655 days. The phases of the Ephemeris have been corrected by − 0.030 d.

1951	Phase	L (yell.)	L (blue)	1951	Phase	L (yell.)	(L blue)
Jun. 14/15	0.102	0.908		Jun. 20/21	0.505	1.994	1.864
	0.119	1.133	0.987	Jun. 23/24	0.659	2.030	1.891
	0.123	1.175	1.059		0.683	2.038	1.901
	0.128	1.213		May 12/13	0.832	1.934	1.857
	0.135	1.283	1.143	May 15/16	1.031	2.009	1.866
	0.140	1.384	1.255	May 4/5	1.162	2.000	1.850
	0.157	1.495	1.375		1.182	1.997	1.860
	0.166	1.580	1.490		1.200	1.979	1.868
	0.170	1.628			1.219	1.914	1.776
	0.182	1.660			1.207	2.008	1.851
	0.183		1.573		1.235	1.928	1.808
	0.187	1.708			1.261	1.908	1.828
	0.188		1.573		1.323	1.867	1.738
	0.192	1.734	1.611		1.349	1.880	1.750
	0.197	1.813		May 18/19	1.375	1.840	1.745
	0.198		1.746		1.131	1.993	1.899
	0.202	1.834			1.163	2.000	1.875
	0.203		1.763		1.190	2.004	1.831
May 31	0.187	1.650	1.530		1.232	2.007	1.836
Jun. 1	0.191	1.734			1.257	1.918	1.811
	0.192		1.610	May 21/22	1.299	1.912	1.820
	0.195	1.770	1.672		1.322	1.850	1.754
	0.199	1.763	1.669	Jun. 7/8	1.341	1.847	1.772
	0.204	1.795			1.433	1.817	1.748
	0.205		1.735		1.467	1.840	1.766
	0.209	1.870			1.479	1.861	1.775
	0.210		1.755		1.503	1.860	1.780
Jun. 3/4	0.297	1.979	1.852		1.548	1.932	1.829
	0.327	1.945	1.841	May 10/11	1.577	1.966	1.846
	0.345	1.965	1.850		1.613	1.910	1.785
	0.363	1.992	1.856	Jun. 9/10	1.631	1.962	1.824
	0.383	1.993	1.870		1.695	1.984	1.868
	0.411	2.015	1.868		1.720	2.013	1.873
May 20/21	0.350	2.005	1.844	May 27/28	1.726	2.020	1.880
	0.395	1.997	1.874	Apr. 29/30	1.739	1.994	1.851
May 6/7	0.397	1.989	1.844		1.824	1.982	1.882
	0.417	1.974	1.852	May 16/17	1.861	1.978	1.866
Apr. 22/23	0.492	1.967	1.860	May 2/3	1.986	2.000	1.849
	0.534	2.025	1.909	Apr. 21/22	2.019	2.009	1.879
	0.584	2.026	1.916		2.371		1.854
Jun. 6/7	0.527	2.010	1.859		2.372	1.980	
	0.548	2.018	1.863	May 8/9	2.404	1.980	1.842
May 26/27	0.737	2.049	1.892	Apr. 25/26	2.402	1.971	1.856
	0.785	2.046	1.919		2.469	1.932	1.832

Normal Points of Observation for TW Drac. (*cont.*)

1951	Phase	L (yell.)	(L blue)	1951	Phase	L (yell.)	L (blue)
May 11/12	2.535	1.938	1.816	Jun. 11/12	2.709		0.773
	2.552	1.962	1.836		2.713	0.918	0.773
	2.568	1.930	1.815		2.717	0.868	
	2.584	1.915	1.806		2.718		0.698
	2.603	1.847	1.739		2.722	0.792	0.638
	2.626	1.682			2.726	0.747	
	2.627		1.601		2.727		0.628
	2.650	1.487			2.731	0.736	
	2.651		1.379		2.732		0.576
	2.672	1.302			2.736	0.657	
	2.673		1.163		2.737		0.507
	2.695	1.049			2.740	0.617	
	2.696		0.903		2.741		0.475
	2.714	0.843			2.746	0.572	
	2.715		0.695		2.747		0.428
	2.722	0.733			2.750	0.520	
	2.723		0.608		2.754	0.493	
	2.733		0.524		2.758	0.462	
	2.739		0.447		2.762		0.316
	2.740	0.583			2.768	0.426	0.286
	2.746	0.531			2.773	0.396	0.257
	2.747		0.389		2.777	0.389	
	2.751	0.486			2.778		0.257
	2.752		0.352		2.780	0.381	
	2.756	0.435			2.781		0.253
	2.757		0.303		2.783	0.372	
	2.767	0.398			2.784		0.242
	2.768		0.302		2.785	0.377	
	2.773	0.385			2.786		0.240
	2.774		0.253		2.790	0.374	
	2.780	0.378			2.791		0.247
	2.781		0.244		2.792	0.374	
	2.785	0.370			2.793		0.254
	2.786		0.248		2.796		0.253
Apr. 27/28	2.584	1.879	1.802		2.797	0.376	
	2.607		1.666		0.000	0.382	
	2.608	1.804			0.002		0.256
	2.641		1.481	May 14/15	2.705	0.972	0.845
	2.644	1.508			2.724	0.794	0.642
	2.670	1.281			2.740	0.608	
	2.671		1.181		2.741		0.480
Jun. 11/12	2.678	1.153			2.771	0.412	
	2.679		1.009		2.772		0.289
	2.693	1.091			2.789		0.259
	2.694		0.957		2.790	0.3855	
	2.698	1.032			0.002	0.383	
	2.699		0.915		0.004		0.253
	2.702	0.992			0.023	0.390	0.252
	2.703		0.828		0.044	0.450	0.317
	2.708	0.952					

NORMAL POINTS OF OBSERVATION FOR Z HERCULIS
Heliocentric phase from epoch 2413086.365 Julian Date
Period 3.992795 days

1951	Phase	L (yell.)	L (blue)	1951	Phase	L (yell.)	L (blue)
May 2/3	0.8034	0.8875	0.8423	May 16/17	2.7602	0.9060	0.8663
	0.8220	0.8858	0.0456		2.790	0.8949	0.8552
	0.8389	0.8885	0.8530		2.924	0.8681	0.8343
	0.9089	0.8858	0.8563	May 24/25	2.8607	0.9020	0.8445
May 6/7	0.8081	0.8906	0.8508		2.8739	0.8876	0.8510
	0.8475	0.8893	0.8504	Jun. 13/14	2.9349	0.8994	0.8510
May 10/11	0.8085	0.8828	0.8525		2.9475	0.9031	0.8485
	0.8267	0.8796	0.8484	May 17/18	3.7729	0.8933	0.8442
	0.9400	0.8929	0.8528		3.7852	0.8820	0.8414
May 22/23	0.8760	0.8895	0.8560		3.7978	0.8779	0.8360
May 26/27	0.9024	0.9010	0.8656		3.8111	0.8852	0.8391
Jun. 15/16	0.9438	0.8917	0.8372		3.8240	0.8836	0.8391
	0.9675	0.8916	0.8477		3.8352	0.8838	0.8363
	0.9808	0.8898	0.8514		3.8517	0.8590	0.8213
	0.9868	0.8897	0.8536		3.8592	0.8383	0.7928
May 3/4	1.8502	0.8924	0.8582		3.8745	0.7781	0.7249
May 7/8	1.8587	0.8841	0.8584		3.9099	0.6311	0.5845
May 15/16	1.8562	0.8803	0.8486		3.9232	0.5837	0.5326
May 27/28	1.8139	0.8851	0.8445		3.9363	0.5494	0.4824
	1.8262	0.8827	0.8478		3.9430	0.5164	0.4464
	1.8364	0.8916	0.8437	May 9/10	3.8005	0.8729	0.8435
	1.8512	0.8850	0.8418		3.8280	0.8531	0.8078
	1.8636	0.8857	0.8373		3.8569	0.8218	0.7838
	1.8779	0.8728	0.8371		3.8732	0.7788	0.7371
	1.8932	0.8675	0.8395		3.8925	0.7014	0.6632
	1.9064	0.8430	0.8231		3.9151	0.6208	0.5651
	1.9242	0.8366	0.8333		3.930	0.5548	0.5071
	1.9442	0.8392	0.8201	May 25/26	3.8102	0.9053	0.8347
	1.9600	0.8170	0.8080		3.8227	0.8782	0.8454
Jun. 16/17	1.9481	0.8123	0.7908		3.8353	0.8736	0.8361
	1.9567	0.8060	0.7831		3.8503	0.8554	0.8206
	1.9660	0.8008	0.7763		3.8825	0.7422	0.7063
	1.9760	0.8042	0.7796		3.8977	0.6994	0.6517
	1.9851	0.8017	0.7838		3.9096	0.6566	0.6075
	1.9888	0.7982	0.7733		3.9233	0.5955	0.5378
	2.0018	0.8069	0.7693		3.9395	0.5425	0.4808
Jun. 20/21	1.9468	0.8145	0.8197		3.957	0.4750	0.4100
	1.9508	0.8101	0.7931	Jun. 14/15	3.9825	0.4112	0.3470
	1.9563	0.8113	0.8073		3.9926	0.3913	0.3273
	1.9744	0.8015	0.7924		3.9961	0.3885	0.3259
	1.9772	0.7989	0.7882	Jun. 22/23	3.9583	0.4606	0.3929
	1.979	0.7949	0.7906		3.9713	0.4303	0.3633
May 8/9	2.8293	0.8930	0.8480		3.9912	0.4014	0.3481
	2.8453	0.8805	0.8456		3.9999	0.3924	0.3305
	2.930	0.8980	0.8481		4.0090	0.3838	0.3233
May 16/17	2.7422	0.9021	0.8618				

Normal Points of Observation for RS Vulpeculae
Heliocentric phase from epoch 2428760.434 Julian Date
period 4.477666 days

1950	Phase	L (yell.)	L (blue)	1951	Phase	L (yell.)	L (blue)
Jun. 8/9	2.082	1.069		Jun. 26/27	0.1972	0.822	0.872
	2.087	1.065			0.2114	0.852	0.913
	2.098	1.061			0.2250	0.882	0.953
	2.102	1.061			0.2390	0.926	1.005
	2.109	1.050			0.2560	0.955	1.024
	2.126	1.034			0.2698	0.988	1.069
	2.132	1.030		May 8/9	0.4868	1.053	1.128
	2.142	1.038		May 26/27	0.5399	1.077	1.128
Jun. 15	2.210	1.045		Jun. 13/14	0.5725	1.053	1.125
Jun. 17/18	2.419	1.035			0.5801	1.042	1.124
Jul. 5/6	2.247	1.039			0.5986	1.067	1.130
Sep. 6/7	2.434	1.057			0.6134	1.045	1.101
					0.6275	1.051	1.132
1951				Jun. 4/5	0.6493	1.053	1.120
May 12/13	0.0024	0.4465	0.4464	May 22/23	1.0644	1.070	1.148
	0.0154	0.4494	0.4447	Jun. 1	1.0609	1.083	1.163
	0.0283	0.453	0.456		1.0775	1.092	1.160
	0.0572	0.5014	0.4928	Jun. 9/10	1.0458	1.072	1.144
Jun. 8/9	0.0140	0.4562	0.4468		1.0689	1.089	1.163
	0.0333	0.4618	0.4690		1.0896	1.083	1.161
	0.0486	0.4718	0.4861	Jun. 13/14	1.6641	1.097	1.172
	0.0650	0.4922	0.5358		1.6821	1.105	1.177
	0.0830	0.5391	0.5487	Jun. 23/24	1.6012	1.109	1.173
	0.1177	0.6136	0.6402		1.6272	1.101	1.170
	0.1344	0.651	0.715		1.6516	1.100	1.172
	0.1510	0.697	0.7325		1.6701	1.104	1.179
	0.1644	0.7301	0.7709	Jun.1/2	2.0237	1.080	1.162
	0.1738	0.760	0.799		2.0486	1.100	1.165
	0.1814	0.776	0.831		2.0691	1.095	1.158
May 21/22	0.0103	0.4641	0.4575		2.0972	1.069	1.147
	0.0234	0.4678	0.4550		2.1243	1.054	1.157
	0.0408	0.4730	0.4819		2.1458	1.061	1.154
	0.0574	0.4910	0.4911	Jun. 10/11	2.0229	1.086	1.171
	0.0726	0.5142	0.5358		2.0371	1.076	1.172
	0.0858	0.5459	0.5654		2.0482	1.075	1.151
Jun. 26/27	0.0492	0.4762	0.4994		2.0614	1.075	1.159
	0.0622	0.4874	0.5107		2.0741	1.075	1.159
	0.0743	0.5206	0.5542		2.0883	1.076	1.171
	0.0889	0.5607	0.5805		2.0979	1.070	1.148
	0.1039	0.5911	0.6064		2.1144	1.050	1.150
	0.1142	0.6064	0.6423		2.1322	1.042	1.141
	0.1296	0.6408	0.6744		2.1475	1.035	1.130
	0.1386	0.6672	0.7091		2.1619	1.043	1.131
	0.1519	0.7045	0.7396		2.176	1.037	1.127
	0.1650	0.7337	0.7934		2.199	1.043	1.139
	0.1764	0.7650	0.8160	May 10/11	2.5253	1.078	1.157
	0.1838	0.7918	0.8381	Jun. 6/7	2.5434	1.100	1.163

NORMAL POINTS OF OBSERVATION FOR RS VULP. (*cont.*)

1951	Phase	L (yell.)	L (blue)	1951	Phase	L (yell.)	L (blue)
Jun. 6/7	2.5685	1.101	1.160	Jun. 16/17	3.5808	1.072	1.138
	2.5914	1.089	1.162	May 16/17	4.0282	1.057	1.134
	2.6081	1.091	1.162	Jun. 12/13	4.058	1.043	1.126
	2.6345	1.097	1.161		4.0747	1.044	1.124
Jun. 15./16	2.5330	1.087	1.178		4.0885	1.033	1.115
	2.5542	1.079	1.186		4.1049	1.035	1.103
	2.5062	1.092	1.165		4.1406	1.031	1.124
	2.5927	1.076	1.174		4.1579	1.024	1.099
	2.6172	1.087	1.163		4.1701	1.021	1.088
	2.6375	1.116	1.190		4.1862	1.011	1.077
May 2/3	3.0017	1.106	1.172		4.1997	0.998	1.076
May 15/16	3.0190	1.102	1.166	Jun. 21/22	4.0403	1.045	1.123
May 24/25	3.0434	1.108	1.177		4.0618	1.042	1.128
Jun. 2/3	3.0118	1.088	1.160		4.0874	1.043	1.116
	3.0293	1.094	1.173		4.0999	1.041	1.127
	3.0444	1.092	1.167		4.1182	1.035	1.123
	3.0578	1.087	1.159		4.1381	1.030	1.115
	3.0685	1.095	1.160		4.1515	1.036	1.117
	3.0875	1.090	1.162		4.1646	1.029	1.110
	3.1032	1.073	1.153		4.1774	1.022	1.100
	3.1175	1.099	1.158		4.1898	1.010	1.084
Jun. 11/12	3.1504	1.110	1.176		4.2109	0.990	1.060
Jun. 20/21	3.1040	1.096	1.146		4.2200	0.950	1.029
	3.1295	1.094	1.155		4.2336	0.931	0.999
May 2/3	3.4438	1.075	1.133	May 21/22	4.4205	0.5002	0.5002
May 20/21	3.586	1.073	1.142		4.4330	0.4834	0.4704
Jun. 7/8	3.5722	1.081	1.161		4.4467	0.4654	0.4683
	3.585	1.093	1.160		4.4675	0.4586	0.4500
	3.5976	1.086	1.160	Jun. 8/9	4.4586	0.4586	0.4556
	3.6229	1.093	1.145		4.4686	0.4482	0.4385
	3.6372	1.072	1.155		4.4753	0.4477	0.4421

PUBLICATIONS OF
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UNIVERSITY OF TORONTO

VOLUME II NUMBER 2

A SECOND CATALOGUE OF VARIABLE STARS IN GLOBULAR CLUSTERS COMPRISING 1,421 ENTRIES

BY

HELEN B. SAWYER

UNIVERSITY OF TORONTO PRESS: 1955

INTRODUCTION

It is fifteen years since the first catalogue of variable stars in globular clusters was published at this observatory by the writer in *Publications of the David Dunlap Observatory*, vol. 1, no. 4, 1939. The numerous requests we have received for this catalogue are evidence that it has proved useful to many workers.

The references to all globular cluster literature were brought up to date in 1947 by the complete listing in the *Bibliography of Individual Globular Clusters* (*David Dunlap Observatory Publications*, vol. 1, no. 20), but among this great number of references the data on variables were not selectively tabulated. Sufficient information has now been added to variable star data to justify a second edition of the variable star catalogue. The present catalogue, in a form similar to that of the first, aims to include all variables which lie within the visible limits of a globular cluster, whether physical members of the cluster or not. When such variables are known, or presumed to be, field stars, this is noted. A few of the variables in this catalogue are also included in the *General Catalogue of Variable Stars* by Kukarkin and Parenago, and its supplements.

Although it would be convenient to have prints of each cluster included in the present catalogue, the difficulty in accomplishing this is too great, and the reader must be referred to the original publications for these. The coordinates in x and y in seconds of arc are listed for practically every variable, but they do not provide, in many cases, as satisfactory identification as could be wished. It is not easy to select the exact centre of a cluster for the point of origin. In clusters where only one variable exists, the identification may be uncertain, and where large numbers have been found, different observers have not always used the same origin.

Table I contains a list, with 1950 positions, of 34 globular clusters which are not included in the main table of this publication. These are clusters for which I have no knowledge of a published search for variables, though several of them are under investigation at the present time. For the most part they are either clusters in the far southern sky, or else difficult objects which can be properly attacked only by a telescope of at least 100 inches. Table I and Table II (the 72 globular clusters which have been searched for variables) together contain the complete list of globular clusters in our galactic system as known to me at the present time. The remarks following Table I explain the changes in the list of globular clusters made since 1947.

TABLE I

THIRTY-FOUR GLOBULAR CLUSTERS NOT SEARCHED FOR VARIABLES

NGC	R.A. 1950	Dec. 1950	NGC	R.A. 1950	Dec. 1950
1261	03^h $10^m.9$	−55° 25′	6388	17^h $32^m.6$	−44° 43′
1841	04 52 .5	−84 05	6401	17 35 .6	−23 53
2158	06 04 .3	+24 06	6440	17 45 .9	−20 21
2682	08 48 .5	+12 00	6441	17 46 .8	−37 02
IC 4499	14 52 .7	−82 02	6453	17 48 .0	−34 37
5824	15 00 .9	−32 53	6496	17 55 .5	−44 15
5927	15 24 .4	−50 29	6517	17 59 .1	−08 57
5946	15 31 .8	−50 30	6558	18 07 .0	−31 45
6101	16 20 .0	−72 06	IC 1276	18 07 .5	−07 15
6139	16 24 .3	−38 44	6569	18 10 .4	−31 50
6304	17 11 .4	−29 24	6624	18 20 .5	−30 23
6316	17 13 .4	−28 05	6637	18 28 .1	−32 23
6325	17 15 .0	−23 42	6638	18 27 .9	−25 32
6342	17 18 .2	−19 32	6642	18 28 .4	−23 30
6352	17 21 .6	−48 26	6652	18 32 .5	−33 02
6355	17 20 .9	−26 19	6681	18 40 .0	−32 21
6380	17 31 .0	−39 03	6717	18 52 .1	−22 47

REMARKS ON TABLE I

Additions to 1947 list

NGC 2158 and 2682 (M67), formerly considered galactic clusters are listed as globular by Rosino and Becker respectively in the I.A.U. report of Commission 37, July 1954.

NGC 6380 has very recently been shown to be globular by Thackeray with the Radcliffe 74-inch; NGC 6558, on some early lists as globular (*Helwan Bull.*, nos. 21, and 22, 1921) is confirmed as globular by Thackeray; correspondence, 1954.

IC 1276, NGC 6642 and 6717 are considered globular by Baade and N. U. Mayall, correspondence, 1948.

Three other clusters not listed as globular in 1947 are now included among those with variables known, in the body of the catalogue. These are the new cluster found by Baade at R.A. 15^h $13^m.5$, and the clusters NGC 6235 and 6535 which vacillate between lists of globular and galactic clusters.

Deletions from 1947 list

The unnumbered object at R.A. 17^h $45^m.7$, Dec. −60° 45′, and NGC 6684 are now dropped from the globular cluster list. From a study of Harvard Southern Station plates, Shapley in a private communication states that they are not globular.

SUMMARY OF DATA ON VARIABLE STARS IN GLOBULAR CLUSTERS

NUMBERS OF VARIABLES

At present 1,421 variable stars are known in the 72 clusters for which there is a record of search. This does not include unpublished or suspected variables. There is a gratifying reduction in the number of variables listed as unpublished, from 99 in 1939 to 41 now. Furthermore in only four clusters are all known variables unpublished. Some of the unpublished variables probably correspond to variables now published by other observers. Counted as suspected variables, in addition to unpublished suspects, are those numbered variables whose variation has been questioned, making a total of 48 suspected variables in 17 clusters. Only three clusters, NGC 5286, 5694, and 6584 have been searched in vain, but the variables found around NGC 6528 are considered by Baade to belong to the rich Milky Way field, so this cluster also is listed as one with no variables.

Since 1939 a total of 329 new variables has been added in 46 clusters. This number includes some which were formerly unpublished or suspected. Contrariwise, some stars formerly considered variable are now listed as doubtful, or have been dropped entirely. This number also includes a few formerly listed only in catalogues of galactic system variables, and now included for the sake of completeness. Nearly half the known globular clusters have been searched in the last fifteen years, which shows considerable activity in this field. The era of finding large numbers of variables in any one cluster seems to be pretty well over. Most of the variable-rich clusters were searched by Professor Bailey in the early years of this century, and there seems to be no more like them.

Table II gives a summary of the number of variables and number of periods known in the 72 globular clusters for which there is a record of search. It has been a little difficult to make this table homogeneous because the sources from which it is drawn were not uniform, and arbitrary decisions had to be made.

The first column of the table gives the NGC number, when available. In the second column is the total number of variables with published identification. The third column contains the unpublished variables (u), and the suspected (s). In a few cases the unpublished variables may no longer exist; when a worker publishes new variables in a cluster, it is sometimes not possible to find out whether they correspond with earlier, unpublished variables of another worker. The totals of suspected variables include those published only as suspects, as well as numbered variables which are now considered doubtful.

Table II, when used alongside Table I of the 1939 catalogue, gives a complete summary of variables in globular clusters to date. The fourth column, headed "New" is the number of variables which have been added since 1939, and the fifth column gives the name of the person responsible for their addition. In most cases this name is that of the discoverer, but occasionally it is that of a worker who first catalogued the variable in a globular cluster.

The sixth column of the table gives the total number of precise periods known, and the seventh, the number which are new since 1939. In the total of new periods I have included not only those periods which are completely new, but also revised periods in which the period as revised differs markedly from the earlier period. Small refinements of period, however, are not counted

TABLE II

Summary of Variable Stars in 72 Globular Clusters

NGC	No. Vars.	Sus. Unpub.	New	Added by	Total Per.	New	Added by	RR Lyr	Prob. RR	Non-RR
104	11	2s	4	McKibben-Nail	3	0		0		9
288	1	2u	1	Oosterhoff	1	1	Oosterhoff	0		1
362	14		0		10			7	1	3
1851	2	1u	0		0			0		
1904	5	1s	1	Rosino	3	3	Rosino	3		1
2298		6u, 5s	0		0			0		
2419	36		0		0			0	23	5
2808		4u, 7s	0		0			0		
3201	77		17	Dowse (16) Wright (1)	59	59	Wright	58		2
4147	4		0		3			3		
4372		3u, 11s	0		0			0		
4590	31		3	Rosino	20	20	Rosino	20	10	1
4833	10	1s	10	Bailey (2) Swope (5) Dowse (2) Wright (1)	9	9	Wright	6	0	4
5024	43		4	v.d. Hoven v. Genderen	32	3	Oosterhoff (2) v.d. H. v.G. (1)	32	6:	1
5053	10		1	Sawyer	10	10	Sawyer (7) Rosino (3)	10	0	0
5139	164		1	Hertzsprung	153	3	van Gent (1) Oosterhoff (1) Kooreman (1)	137	3:	21
5272	187	2s	3	Schwarzschild(1) Sandage (2)	171	19	Martin	170	3:	3
5286	0		0		0			0	0	0
5466	18		4	Sawyer	18	18	Sawyer	18	0	0
5634	7		7	Baade	1	1	Baade	1	6	0
5694	0				0			0	0	0
Baade	5	5s	5	Rosino	0			0	5	
5897	4		4	Sawyer	0			0	5	
5904	97	1s	11	Oosterhoff	92	26	Oosterhoff	90	3	4
5986	1		0		0			0		
6093	7		4	Sawyer	1	1	Sawyer	0	3	3
6121	43		11	de Sitter	41	25	de Sitter, Oosterhoff	41	0	2
6144	1		1	Sawyer	0			0		
6171	24		0		0			0	22	1
6205	10	5s	5	Sawyer (4) Arp (1)	6	5	Sawyer (3) Kollnig- Schattschneider (1) Arp (1)	3	2	6
6218	1		0		1	0		0	0	1
6229	22		21	Baade (20) Sawyer (1)	0			0	20	2

TABLE II (*cont.*)

NGC	No. Vars.	Sus. Unpub.	New	Added by	Total Per.	New	Added by	RR Lyr	Prob. RR	Non-RR
6235	2		2	Sawyer	0			0	2	
6254	3		1	Arp	2	1	Arp	0	0	3
6266	26		0		0			0		
6273	4		4	Sawyer	0			0	2	1
6284	6		6	Sawyer	0			0		
6287	3		3	Sawyer	0			0		
6293	5		2	Sawyer	0			0	4	
6333	13		12	Sawyer	11	11	Sawyer	11	1:	
6341	16	1s	0		13	4	Oosterhoff	12		1
6356	5		5	Sawyer	0			0		
6362	15	2u	0		0			0		
6366	2		2	Sawyer	0			0	1	
6397	3		1	Swope	3	1	Swope, Greenbaum	1	0	2
6402	72		0		3	0		0	60	4
6426	11		11	Baade	0	0		0		
6522	9		9	Baade	8	8	S. Gaposchkin	8	0	1
6528	0		0	Baade	0			0		
6535	1	1u	1	Sawyer	0			0		
6539		1u	0		0			0		
6541	1		0		0			0		
6553	6	2s	6	Thackeray (5) M. Mayall (1)	3	3	Thackeray	3	0	3
6584	0		0		0			0		
6626	16		7	Sawyer	1	1	Sawyer	0	7	5
6656	24	1s	8	Sawyer	22	15	Sawyer	18	0	6
6712	12	3u	11	Sawyer (10) Oosterhoff (1)	1	1	Oosterhoff	0		2
6715	28		28	Rosino	0			0	24	4
6723	19		0		19	0		19	0	0
6752	1		0		0	0		0		
6760	4	2u	4	Sawyer	0			0		
6779	12		9	Sawyer (7) Rosino (2)	4	4	Sawyer (2) Rosino (2)	2	2	7
6809	6		4	King	5	5	King	5	1	0
6838	4		4	Sawyer	0	0		0		3
6864	11	5s	0		0	0		0		
6934	51		0		0	0		0	45	
6981	39		8	Sawyer (7) Rosino (1)	27	12	Rosino	27	7	
7006	40	1s	32	Hubble, Sandage	1	1	Hubble, Sandage	0	39	1
7078	93	8u? 2s	29	Rosino	61	0		60	28	2
7089	17		0		17	1	Sawyer	13	0	4
7099	4		1	Rosino	3	3	Rosino	3	0	1
7492	1	8u, 6s	0		0	0		0		

as new periods. The next column gives the name of the computer of the period.

The last three columns of the table give the types of variables in the cluster. Under the heading "RR Lyr" is given the number of RR Lyrae periods actually determined and published in the cluster. The following column gives the number of stars which are probably RR Lyrae type, though without published periods. A blank indicates that no definite number can be assigned at present. For example, in a cluster like NGC 6266 where no magnitudes of variables have ever been published, no estimate as to the number of probable RR Lyrae stars appears justified. The final column gives the number of non-RR Lyrae stars in the cluster. This number includes all stars, with both known and unknown periods, which present observations indicate are not RR Lyrae variables. Because these stars are of increasing importance, each one of them is listed individually in Table III. The total of the last three columns of Table II will not necessarily equal the total number of variables in the cluster, since some variables remain of unknown type.

Figure 1 shows the frequency distribution of the number of variables per

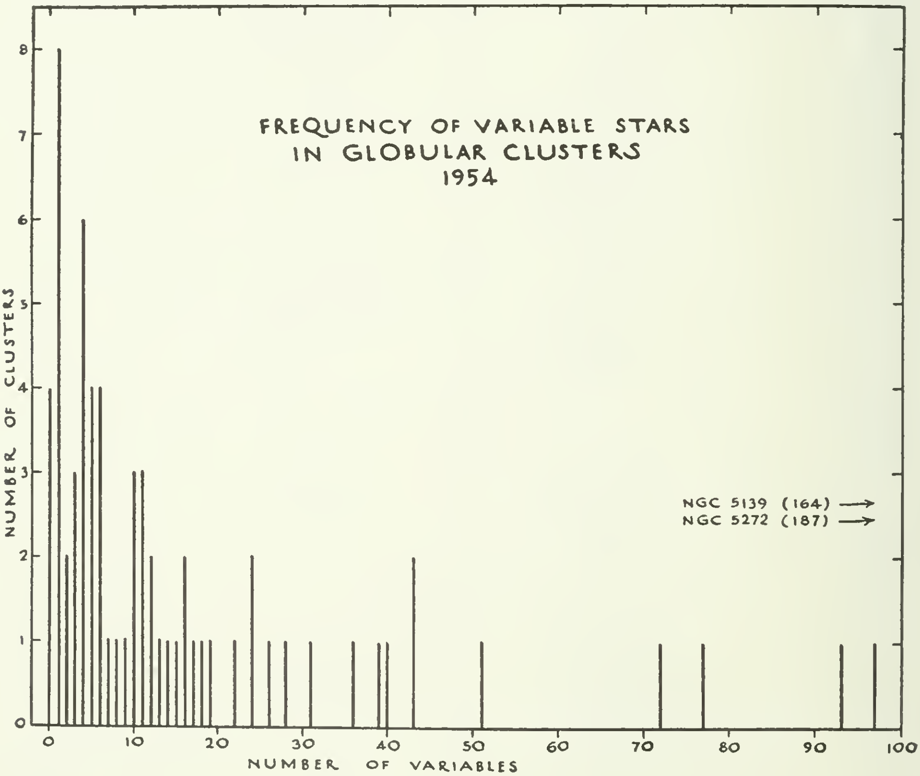

FIGURE 1. Distribution of the known, published variables per cluster for 68 clusters.

cluster, giving the numbers of clusters which have the number of variables indicated by the abscissa. More than 50 per cent of the clusters examined, 37 in all, have 10 variables or less. On the other hand, 18 clusters, about 25 per cent, have more than 20 variables. It is not possible to say at present how the observed frequency of variables in these clusters will compare with the true frequency; we might comment, however, that there have been very few cases in which, once a globular cluster had been searched for variables, further work changed it from a variable-poor to a variable-rich category. That is to say, additional hunting for variables increases the numbers in a moderate rather than a radical way.

This actual frequency of variables in globular clusters is interesting because it is at variance with common impressions that variable stars abound in globular clusters. Of the 72 clusters now examined, only 7 contain more than 50 variables each; and probably few, if any, clusters will be added in the future to this list of variable-rich objects. Since most of the clusters left to be studied are small and difficult, they will almost certainly increase the number with few variables. Three-quarters of the clusters examined contain less than 20 variables. It is rather surprising to note that the most frequent number of variables found in a globular cluster is one!

The richest cluster still remains NGC 5272, Messier 3, with 187 variables and 2 suspected. A close second is Omega Centauri, NGC 5139, with 164. Next in order of richness are Messier 5 (NGC 5904) and Messier 15 (NGC 7078), with about half as many variables, 97 and 93 respectively.

NUMBER OF KNOWN PERIODS

Of the known variables, periods have now been determined for 843 in 38 clusters, compared with 656 in only 20 clusters in 1939. Hence though the studies of the past fifteen years have not enormously increased the number of known variables or new periods, they have brought us a better over-all picture of the variable content of the entire system of globular clusters than we had earlier when the four rich clusters cast their weight too heavily.

Of the periods now listed, 274 are new, in 30 clusters. For a number of clusters there have been revisions and redeterminations of periods. For statistical purposes I have counted the period as new only if the value was changed by more than 0.01 day.

DISTRIBUTION OF PERIODS AND TYPES

There are 779 definite RR Lyrae periods known in 28 clusters. In addition there appear to be at least 335 more stars which are probably of this character. Probably also most of the 185 stars for which the data do not permit a definite assignment of type will also prove to be of this class.

Attention has often been drawn to the difference in frequency of period from one cluster to another. It is interesting, however, to portray the frequency of all known RR Lyrae periods in globular clusters. This is shown in figure 2 for period intervals of 0.01 day. The outstanding feature of the distribution is the conspicuous gap in periods slightly under 0.45 day. It is difficult to think that this gap is caused by any observational selection (unless some factor causes stars of this period to have a very small range). There certainly would appear to be no reason why periods of this length are more difficult to determine. The double maximum in this distribution of period frequency raises the question as to whether we are concerned with two different types of stars. Are RR Lyrae variables whose periods are shorter than 0.45 day the same kind of variable as those whose periods are longer? Numerous studies of the RR Lyrae stars in the galactic system, for example by Kukarkin, Struve and Joy, and Shapley suggest that all RR Lyrae stars do not constitute a homogeneous group.

Nearly 10 per cent of the known variables in globular clusters are definitely not RR Lyrae stars, 122 stars in 36 clusters. Table III, which is similar to Table II in the first catalogue, lists these 122 stars which are within the visible limits of globular clusters and are not RR Lyrae variables. The table in the present catalogue is considerably more inclusive than the earlier one, which was restricted to stars with known periods over a day. The present table includes the W Ursae Majoris types such as Var. 141 in NGC 5272, stars with irregular light variation, and stars of unknown type which are listed as probably not RR Lyrae stars. Many of these stars are field variables, and not cluster members. Any definite information in this regard has been listed, but in most cases more observational evidence is necessary to decide whether a variable is an actual cluster member.

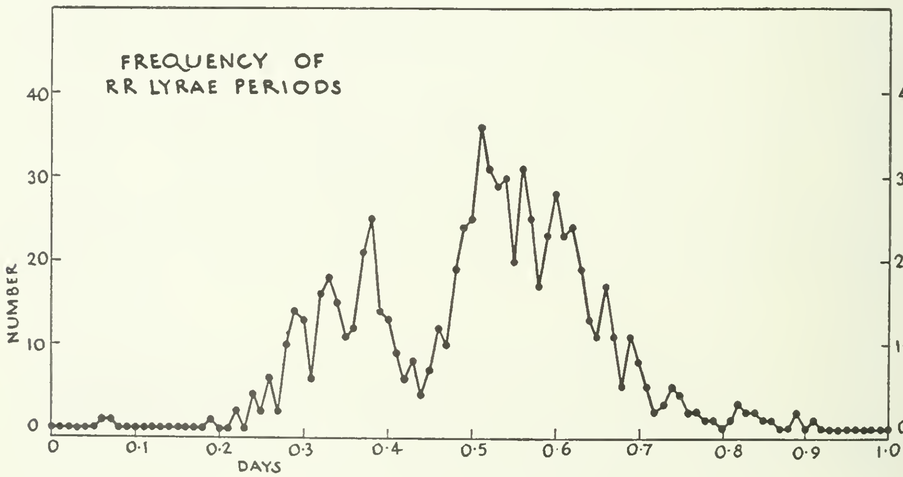

FIGURE 2. Numbers of RR Lyrae periods at intervals of 0.01 day for 781 periods in 28 globular clusters.

TABLE III

Variables which are not RR Lyrae Stars

NGC	No.	Magnitudes Max.	Min.	Period (days)	Remarks
104	1	11.3	[16.0	212.40	long per.
	2	11.55	15.3	202.84	long per.
	3	11.35	16.1	192.34	long per.
	4	12.0	14.0		cycles 150±
	5	13.0	14.0		irreg.
	7	13.3	13.8		irreg.
	8	12.7	14.7		cycles 150±
	10	13.1	13.6		irreg.
	12	13.2	14.0		irreg.
288	1	13.5	14.1	103.	semireg.
362	2	13.0	14.5	105.22	prob. Small Cloud
	8	14.8	16.3	3.901447	prob. Small Cloud
	10	14.7	16.2	4.20519	prob. Small Cloud
1904	2	14.2	14.8		irreg. or semireg.
2419	1	17.59	18.32		bright irreg.
	8	17.50	18.10		bright irreg.
	10	17.31	17.93		bright irreg.
	18	17.84	18.53		bright irreg.
	20	17.65	18.16		bright irreg.
3201	65	14.01	15.03	1.6599990	eclipsing
	68				red, prob. long per.
4590	27*	10.88	15.04		FI Hya, field, long per.
4833	2	13.0	16.2	333.7	RZ Mus, long per.
	9	14.5	15.16	87.7 or 1	HV 10781
	10	15.14	15.9		Cepheid, HV 10782
	11	14.5	16.0:	303.8	long per., HV 10783
5024	24	15.71	16.43	3?	type unknown
5139	1	10.7	12.6	58.7027	RV Tauri type
	2	]13.06	16.12	484.	per. poss. 242[d]
	6	13.84	15.24		irreg.
	17	14.18	14.61	60:	irreg.
	29	12.44	13.50	14.72429	Cepheid
	42	12.5	14.9	149.4	
	43	13.41	14.55	1.1568183	Cepheid
	48	13.09	13.95	4.474293	Cepheid
	53	13.30	13.87	87:	irreg.
	60	13.32	14.48	1.349464	Cepheid
	61	13.72	14.48	2.27358	Cepheid
	78	14.17	14.84	1.1681179	eclipsing
	92	14.10	14.58	1.3450659	Cepheid
	129	14.18	14.74		irreg., long per.?
	133	13.74	14.53	0.31709628	W UMa type, field
	138	12.5	13.6	74.6:	irreg.
	148	12.9	13.8	90:	irreg.
	152	12.8	13.7	124:	irreg.

TABLE III (*cont.*)

NGC	No.	Magnitudes Max.	Min.	Period (days)	Remarks
	161	13.3	13.8		irreg.
	162	12.9	13.6		irreg.
	164	13.7	14.0		irreg., prob. red
5272	95*	13.31	14.50	103.19	semireg.
	141	14.88	15.65	0.2695477	RV CVn, W UMa type
	154*	11.86	13.5	15.2828	W Vir type
5904	42*	10.76	12.46	25.738	Cepheid
	50*	13.6	14.0	106?	irreg. or semireg.
	84*	11.00	12.77	26.5	Cepheid
	101	17.16			SS Cyg type
6093	1*	13.1	14.5	15.70	W Vir type
	6	9.3	15.8	177.13	S Sco; prob. field
	7	9.5	15.5	222.53	R Sco; prob. field
	Nova	6.8			Nova T Sco 1860
6121	4*	11.0	13.0	65±	semireg.
	13*	12.37	13.08		semireg.
6171	1	]14.16	[16.75		prob. long per.
6205	1*	13.27	14.61	1.45899	Cepheid
	2*	12.67	13.90	5.11003	Cepheid
	6*	13.90	14.73	2.11283	Cepheid
	10*	13.4	13.7		semireg.
	11*	12.92	13.71	92.5	semireg.
	15	13.32	13.67		irreg.
6218	1*	11.9	13.2	15.508	W Vir type
6229	8	15.30	16.64		Cepheid
	22	15.2	16.3		prob. slow
6254	1*	12.8	13.2		semireg.
	2*	11.91	13.34	18.754	W Vir type
	3	13.10	13.82	7.87	Cepheid
6273	2	13.4	14.7		Cepheid?
6341	14	14.8	15.1	0.346178	W UMa type, field
6397	1	11.2	16.0	314.6	long per., poss. field
	2	13.8	14.8	45 or 60	semireg., poss. field
6402	1*	14.3	16.0	18.75	W Vir type
	2*	15.4	16.3	2.7952	Cepheid
	7*	14.9	16.2	13.59	W Vir type
	17*	14.8	15.7		field? type unknown
6522	7	17.02	17.61		irreg., field
6541	1	12.5	[16		prob. long per.
6553	Nova	7.5			Nova Sgr 1943
	4			]100	
	5			]100	
6626	2	14.3	14.8		poss. slow
	3	14.6	15.4		poss. slow
	4*	13.6	14.8	14.0	W Vir type
	6	14.3	15.2		per. many weeks
	10	13.5	14.6		slow

TABLE III (*cont.*)

NGC	No.	Magnitudes Max.	Min.	Period (days)	Remarks
6656	5*	12.0	12.8		slow
	8*	12.0	12.7		semireg.
	9*	12.7	13.3		semireg.
	11*	12.9	13.8	1.69050	Cepheid
	14*	13.8	[15.5	200.2	long per., field
	17	14.6	[15.		prob. irreg.
6712	2	14.0	14.9	105	AP Sct; RV Tau type?
	7	14.2	[17.0		prob. long per.
6715	8	16.8	17.6		poss. not RR Lyr
	12	16.7	17.3		poss. not RR Lyr
	19	16?	16.5		poss. not RR Lyr
	25	16.8	17.4		poss. not RR Lyr
6779	1*	15.2	16.3	1.510019	Cepheid
	3*	14.4	15.1		semireg.
	5	14.4	15.2	43±	semireg.
	6*	12.9	14.8	90.02	RV Tau type
	7	15.6	16.3	40–50	semireg.
	8	15.9	16.7	68±	semireg.
	9	15.6	16.1		semireg.
6838	1	13.5	14.9		slow, Z Sge
	2	13.8	14.7		slow
	3	15.2	17.0		eclipsing
7006	19			252:	long per.
7078	1*	14.39	15.75	1.437478	Cepheid
	86	13.4	14.6		prob. Cepheid
7089	1*	13.29	14.78	15.5647	W Vir type
	5*	13.30	14.47	17.5548	W Vir type
	6*	13.07	14.31	19.3010	W Vir type
	11*	12.12	13.25	67.086	RV Tau type
7099	4	16.4	[18	11–15	U Gem type

*Spectrum available.

Almost all types of variable stars are represented. Table III lists 2 novae, 15 Cepheids with periods up to 10 days, 13 stars with periods from 10 to 26 days, either Cepheids or W Virginis stars, 18 long period variables, 3 eclipsing variables, 3 W Ursae Majoris, 2 SS Cygni, and 4 RV Tauri stars, as well as 39 irregular and semi-regular variables of several kinds. The remainder are of indefinite type. No flare stars or R Coronae Borealis variables have been noted as yet.

Description of the Catalogue

The catalogue contains every cluster for which there is a published record of a search for variables, and a few others for which the unpublished data have been supplied to the writer. The clusters are arranged in order of NGC number, or, lacking that, by right ascension. If the cluster has a Messier number, it is given. The right ascension and declination are for the equinox of 1950.

The variables are numbered according to the number given by the discoverer except in a few cases where an adjustment has had to be made. The x and y co-ordinates are given in seconds of arc and correspond in direction to right ascension and declination. Whenever they have been published, magnitudes, epochs, and periods are given. A blank in these columns indicates lack of published data. When an observer has given a table of maximum and minimum magnitudes, these have been taken. However, in many cases the writer has had to read these values from published measures of many plates by taking the brightest and faintest estimates of magnitude for the variable. Epoch of maximum gives the number of days past J.D. 2,400,000.000. For stars in clusters like Omega Centauri and Messier 3 where many investigations of small period changes have been made, only one value (usually the latest or best determined) is given for the period.

Suspected variables have not been included in the catalogue in general, except for those where numbers had been previously assigned. Announced variables which are now considered not to vary have been left in the catalogue so that a reader may be aware of them, but they have not been included in the totals of known variables.

In an attempt to clear up some of the confusion which has existed for years in Messier 3, NGC 5272, the writer has identified the variables whenever possible in von Zeipel's catalogue. A similar process has been followed for Messier 15, NGC 7078, with Küstner's catalogue, since Rosino published some of these identifications for his new variables in that cluster.

When necessary, notes pertaining to a cluster are given after the data on that cluster.

References to Literature on Variable Stars in Globular Clusters

To the catalogue is appended a complete bibliography of literature on variable stars in globular clusters. The 125 references given in the 1939 catalogue have now been expanded to 193, including 6 references before 1939 found after the publication of that list. This total does not include references to unpublished correspondence, which contains much vital information. As formerly, the references are arranged by years, and alphabetically under author for any given year. At the end of each cluster, the list of numbers indicates the references to that cluster, and special note is made of the references in which photographs or charts of the clusters giving identification of the variables can be found.

Acknowledgments

In the preparation of this catalogue I have had a great deal of co-operation from astronomers working on variables in clusters, who sent results in advance of publication. It is a pleasure to acknowledge help from the following: Dr. Harlow Shapley and his co-workers at the Harvard College Observatory, including Mrs. Virginia McKibben-Nail, Miss Frances Wright, Miss Arville Walker, and Mr. Ivan King; from the astronomers at Mount Wilson and Palomar Observatories, especially Dr. Walter Baade, Dr. Allan Sandage, Dr. Halton Arp, and Miss Henrietta Swope; from Dr. David Thackeray of the Radcliffe Observatory, Dr. P. Th. Oosterhoff of the Leiden Observatory, and Dr. L. Rosino of the Bologna Observatory. Dr. H. Wilkins of the National Observatory of Argentina has been exceedingly helpful in picking up inconsistencies or errors in existing literature and drawing them to my attention, in order that they may be remedied as far as possible in this edition of the catalogue. The identification of the variables in Messier 3 with von Zeipel's numbers was aided by charts supplied from Mount Wilson and Palomar Observatories; much of the computation was done at this observatory by Mr. Donald Morton. I am deeply grateful to the Publications Fund of the University of Toronto Press for help with this publication.

Richmond Hill, Ontario
September 30, 1954

SECOND CATALOGUE OF VARIABLE STARS IN GLOBULAR CLUSTERS

NGC 104 (47 Tucanae) α 00^h 21^m.9, δ −72° 21′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 36.8	−112.6	11.3	[16.0	12717.	212.40	
2	+ 64.7	−193.9	11.55	15.3	12685.	202.84	
3	+ 328.4	+ 52.8	11.35	16.1	12755.	192.34	
4	− 18.8	−160.4	12.0	14.0		150±	cycles
5	+ 271.9	−284.6	13.0	14.0			irreg.
6	+ 97.3	−103.8	13.2	13.8	var?		
7	+ 349.2	−113.0	13.3	13.8			irreg.
8	+ 16.0	+ 57.0	12.7	14.7		150±	cycles
9	− 108	− 78	13.5	14.5		short	HV 810
10	+ 72	+702	13.1	13.6		irreg.	HV 811
11	+ 306	+138	13.2	14.0		irreg.	HV 813
12	+1254	−348	13.6	14.4		short	HV 814

A suspected variable, HV 812, is not listed above.
Refs. 9, 14, 20, 68, 139, 173, 175. Plate in 20.

NGC 288 α 00^h 50^m.2, δ −26° 52′

1	− 55	+ 79	13.5	14.1	25576	103

2 unpublished variables?
Refs. 87, 150 with chart.

NGC 362 α 01^h 01^m.6, δ −71° 07′ (Corrected position)

1	− 246.2	− 67.6	14.9	16.1	23751.558	0.5850512	
2	+ 41.4	−204.4	13.0	14.5	24391.8	105.22	HV 206
3	+ 93.6	−143.2	14.6	16.1	23604.806	0.4744151	
4	− 50.2	− 27.3	14.0	15.8			
5	− 79.2	− 31.9	15.1	16.4	24025.729	0.4900846	
6	+ 82.4	+ 15.5	14.9	16.3	24461.642	0.5146080	
7	+ 131.1	− 21.2	14.8	16.0	24468.687	0.5285492	
8	+ 33.4	−308.5	15.0	16.5	24433.677	3.901447	HV 212
9	− 400.4	+224.4	14.7	16.0	24404.670	0.5476126	
10	+ 282.8	−381.8	14.9	16.4	23315.643	4.20519	HV 214
11	− 136.1	− 26.0	15.1	16.0			
12	− 30.4	−115.4	15.2	16.1	24391.839	0.65254518	
13	+ 14.5	+ 38.8	14.6	16.3			
14	− 23.8	− 66.8	14.8	16.2			

Refs. 11, 14, 20, 90, 94, F, J. Plate in 20, 94.

CATALOGUE—*Continued*

NGC 1851 α 05^h 12^m.4, δ −40° 05′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 261	− 9	14	15½			
2	− 45	+ 30	14	15½			

1 unpublished variable.
Refs. 72, 87. No map.

NGC 1904 (Messier 79) α 05^h 22^m.2, δ −24° 34′

1	+ 29.6	−199.6	var.?				med. 16.0
2	+ 78.3	− 68.3	14.2	14.80			semireg.
3	+ 34.8	− 64.4	15.9	16.7	34032.40	0.73602	
4	+ 93.4	− 50.1	15.6	16.7	32877.50	0.63492	
5	− 11.6	+ 20.2					
6	− 70.8	+115.6	16.0	16.6	32940.25	0.33522	

Refs. 14, 20, 181. Plates in 20, 181.

NGC 2298 α 06^h 47^m.2, δ −35° 57′

6 unpublished variables, 5 suspected.
Ref. F.

NGC 2419 α 07^h 34^m.8, δ +39° 00′

1	+ 40	− 52	17.59	18.32			irreg.
2	− 4	− 19					
3	+ 52	− 24	18.66	19.96			
4	+ 80	− 15	18.84	19.65			
5	+ 33	+ 47	18.75	19.72			
6	+ 56	−127	18.86	19.64			
7	+ 91	+ 87	18.69	19.77			
8	− 17	+ 41	17.50	18.10			irreg.
9	− 32	+ 88	18.59	19.76			
10	+ 20	− 51	17.31	17.93			irreg.
11	+ 95	− 8	18.55	19.81			
12	+ 133	+111	18.69	19.71			
13	+ 101	− 10	18.55	19.75			
14	− 115	− 13	18.81	19.62			
15	+ 62	+ 40	18.62	19.76			
16	+ 47	+ 72	18.77	19.85			
17	+ 109	+111	18.65	19.75			
18	− 15	+114	17.84	18.53			irreg.
19	− 107	− 40	18.77	19.86			
20	− 28	+ 45	17.65	18.16			irreg.

CATALOGUE—*Continued*

NGC 2419

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
21	− 55	+ 30	18.76	19.74			
22	+ 109	− 5	18.60	19.84			
23	+ 27	+ 79					
24	− 147	− 10	18.94	19.58			
25	− 59	+ 38	18.78	19.70			
26	− 70	− 50					
27	+ 19	−103	19.10	19.55			
28	− 192	+ 59	18.72	19.78			
29	− 58	− 7	19.01	19.92			
30	− 26	+ 23					
31	+ 154	−146	19.08	19.53			
32	− 19	+ 48	18.60	19.71			
33	+ 47	− 17	19.11	20.13			
34	+ 21	+157	19.00	19.66			
35	+ 43	+ 8	18.88	20.00			
36	+ 23	+ 44	19.10	19.83			

Ref. 108, with plate, I.

NGC 2808 α 09^h 10^m.9, δ −64° 39′
4 unpublished variables, 7 suspected.
Refs. F, N.

NGC 3201 α 10^h 15^m.5, δ −46° 09′

1	+ 59	−118	14.71	15.76	22484.504	0.6048761	
2	+ 29	−117	14.61	15.60	28272.352	0.5326722	
3	+ 182	− 43	14.90	15.49	22100.533	0.5994093	
4	+ 155	+ 3	14.76	15.60	23198.539	0.6300006	
5	+ 42	− 24	14.63	15.75	23172.676	0.5015359	
6	− 116	−143	14.50	15.55	23166.545	0.5256131	
7	− 91	−189	14.87	15.35	23566.533	0.6303322	
8	− 69	− 99	15.00	15.46	23166.613	0.6286280	
9	− 51	− 91	14.86	15.57	23506.605	0.5266970	
10	− 181	+235	14.66	15.59	22429.597	0.5351571	
11	− 104	+112	14.87	15.40	29696.446	0.2990471	
12	− 86	+108	14.50	15.53	23547.577	0.4955583	
13	− 160	+ 92	14.57	15.50	23163.664	0.5752145	
14	− 156	+133	14.61	15.67	23961.495	0.5092897	
15	− 279	−173	14.34	15.43	23164.572	0.5346644	
16	− 197	−238					
17	+ 11	− 25	14.84	15.80	28253.276	0.5655773	
18	+ 23	− 24					
19	+ 23	+317	14.54	15.45	29696.361	0.5250201	
20	+ 39	+284	14.45	15.55	29273.322	0.5291064	

CATALOGUE—*Continued*

NGC 3201

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
21	+ 94	+135	14.75	15.62	23191.514	0.5666509	
22	− 100	− 56	14.72	15.45	23165.679	0.6059842	
23	− 49	− 50					
24	− 339	+ 17	14.76	15.35	23166.521	0.5889798	
25	+ 93	+173	14.68	15.53	23566.533	0.5147963	
26	+ 219	−140	14.80	15.61	23198.542	0.5689949	
27	+ 58	−323	14.11	15.32	23164.508	0.4842943	
28	+ 66	− 48	14.98	15.74	23932.478	0.5786766	
29	− 256	+113					
30	− 289	+272	14.56	15.36	23166.488	0.5158559	
31	+ 182	+131	14.65	15.51	23505.620	0.5194894	
32	+ 195	+199	14.55	15.56	23190.624	0.5611656	
33	+ 48	− 40	not var.				
34	+ 296	+285	14.37	15.62	23547.577	0.4678883	
35	− 11	+121	14.90	15.45	22484.504	0.6155244	
36	− 108	− 11				0.484	
37	− 68	− 74					
38	− 61	− 60	14.70	15.60	23877.612	0.5091616	
39	+ 41	+ 54	14.83	15.80	23181.537	0.4832092	
40	− 96	+ 68					
41	+ 291	+ 28					
42	− 301	+197	14.39	15.44	27565.286	0.5382490	
43	− 377	+ 15	14.80	15.39	23166.665	0.6761289	
44	+ 31	+ 67	15.01	15.66	23190.635	0.6107344	
45	+ 127	− 32	14.85	15.60	23165.684	0.5374165	
46	− 396	−510	14.56	15.35	23167.570	0.5431990	
47	+ 108	+245					
48	− 252	+ 12					
49	− 38	+151	14.74	15.43	23172.499	0.5814870	
50	− 13	+ 27					
51	− 205	− 26	14.37	15.50	28273.328	0.5205454	
52	+ 14	−812					
53	− 873	−758	14.57	15.38	23191.540	0.5334705	
54	+ 671	−804	14.67	15.44	23548.660	0.5558721	
55	− 338	+767					
56	+ 246	+ 94	14.95	15.62	23164.591	0.5903376	
57	+ 288	− 72	14.80	15.58	28628.317	0.5934373	
58	+ 346	− 80	14.94	15.45	23164.538	0.6220418	
59	− 490	− 70	14.32	15.40	23528.608	0.5177106	
60	− 850	+ 95	14.22	15.47	23165.526	0.5035723	
61	−1125	+175					
62	−1060	−186	14.62	15.28	23506.538	0.5697558	
63	−1000	+ 59	14.36	15.39	23914.582	0.5680998	
64	− 646	+863	14.40	15.36	23191.538	0.5224218	
65	− 544	+797	14.01	15.03	26417.421	1.6599990	ecl.
66	− 398	+289	not var.				

Catalogue—*Continued*

NGC 3201

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
67	− 374	−120					
68	− 283	+846					long per.
69	− 221	+995	14.34	15.50	23914.575	0.5122704	
70	− 221	− 13	not var.				
71	− 182	−117	14.65	15.46	23506.605	0.6011859	
72	− 161	+596	not var.				
73	− 128	+86	14.39	15.60	23172.569	0.5199500	
74	− 94	+ 36	not var.				
75	− 81	+147	not var.				
76	− 62	− 42				0.526	
77	− 10	− 52	14.67	15.40	22429.592	0.5676648	
78	− 8	−143					
79	+ 10	−101	not var.				
80	+ 60	+ 23					
81	+ 96	−153					
82	+ 161	−166	not var.				
83	+ 177	+172	14.58	15.67	23190.624	0.5451918	
84	+ 358	+703	14.65	15.43	22077.566	0.5136787	
85	+ 569	−403	not var.				
86	+ 611	−315	not var.				
87	+1013	−460	14.65	15.30	23164.633	0.6038866	

Unpublished epochs and magnitudes, ref. Q.
Refs. 46, 59, 127, 140 with print.

NGC 4147 α 12^h 07^m.6, δ +18° 49′

1	− 100.1	− 45.7	15.90	16.95	25324.68	0.4993
2	− 20.2	− 28.8	15.95	17.25	25305.541	0.4920
3	− 28.5	− 35.3	16.32	16.78	25321.528	0.3834
4	+ 1	+ 18	16.5	17.1		

Refs. 36, 85, 89. Print in 85.

NGC 4372 α 12^h 23^m.0, δ −72° 24′

3 unpublished variables, 11 suspected. Ref. N.

NGC 4590 (Messier 68) α 12^h 36^m.8, δ −26° 29′

1	− 280	+109	15.55	16.11	34067.792	0.349599
2	− 168	− 45	15.05	16.29	33663.695	0.5781805
3	− 140	+ 91	15.40	16.15	33661.66	0.4128?
4	− 117	−131	15.65	16.20		0.2864?
5	− 56	+170	15.47	16.11	33741.570	0.3878

CATALOGUE—*Continued*

NGC 4590

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
6	− 54	+ 17	15.75	16.07	33741.542	0.269261	
7	− 50	− 79	15.71	16.07	34093.461	0.279294	
8	− 38	−134	15.69	16.08	34093.509	0.280560	
9	− 31	+ 40	15.43	16.28			
10	− 25	− 16	15.28	16.62			
11	− 18	−112	15.65	16.16	33741.541	0.369499	
12	− 10	− 1	15.07	16.23			
13	− 6	− 56	15.72	16.11	34149.415	0.265638	
14	− 4	+218	15.02	16.25	33663.714	0.5567753	
15	+ 9	+ 58	15.65	16.36			
16	+ 11	+ 80	15.65	16.22	34071.536	0.418330	
17	+ 16	− 75	15.65	16.60			
18	+ 19	− 96	15.69	16.19	33741.46	0.367345	
19	+ 33	+ 70	15.65	16.20			
20	+ 34	−114	15.69	16.14	34118.451	0.385763	
21	+ 48	+ 8	15.82	16.60			
22	+ 61	− 22	15.30	16.52			
23	+ 64	+380	14.85	16.13	34506.392	0.658898	
24	+ 74	− 8	15.64	16.13	34093.522	0.376495	
25	+ 141	+123	15.01	16.15	33770.450	0.6415354	
26	+ 158	− 44	15.63	16.11	33799.370	0.413217	
27	+ 380	+263	10.88	15.04		long	Sp., field
28	+ 440	+160	14.81	16.18	34120.498	0.6067773	
29	+ 287	−252	15.65	16.15			
30	+ 112	− 78	15.70	16.15			
31	− 109	+ 90	15.49	16.10	33741.461	0.399658	

Variables Nos. 29, 30, 31 are unpublished, found by Rosino, ref. L.
Refs. 44, 49, 117a, 159, 186, L. Print in 49.

NGC 4833 α 12ʰ 56ᵐ.0, δ −70° 36′

1	− 264	+468	15.32	15.86	29375.251	0.750101	RY Mus
2	+ 378	−354	13.0	16.2:	26166	333.7	RZ Mus
3	0	+ 6	15.46	15.9	29363.248	0.744526	HV 10775
4	0	+ 24	15.24	15.88	29381.249	0.655536	HV 10776
5	+ 132	− 66	15.4	16.0	29381.240	0.629414	HV 10777
6	+ 120	+120	15.3	15.9	29381.297	0.653967	HV 10778
7	+ 72	− 6	15.49	16.05:	29374.256	0.668422	HV 10779
8	− 168	+498	15.59	15.79	var?		HV 10780
9	− 42	− 6	14.5	15.16	28635	87.7:	HV 10781
10	+ 72	+414	15.14	15.9			HV 10782
11	− 336	−828	14.5	16.0:	24320	303.8	HV 10783

Refs. 65, 87, 149.

CATALOGUE—*Continued*

NGC 5024 (Messier 53) α 13^h 10^m.5, δ +18° 26′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 9.6	−171.0	16.05	16.95	22789.486	0.6098214	
2	− 78.0	−183.6	16.38	16.88	22787.498	0.3861005	
3	− 60.6	−138.0	16.14	16.93	22763.412	0.6306111	
4	− 169.5	−156.6	16.41	16.84	23113.482	0.3851668	per. var.
5	− 237.0	−258.0	15.89	16.98	22790.515	0.6394274	
6	+ 123.6	+ 13.5	16.08	17.11	22790.620	0.6640168	
7	+ 79.5	+ 83.5	16.02	16.95	22763.515	0.5448337	
8	+ 72.0	+ 60.0	16.28	16.95	22762.584	0.615531	
9	+ 67.5	− 40.5	16.03	17.10	22789.484	0.6003729	
10	− 138.6	+ 54.0	15.90	16.98	22789.443	0.6082560	
11	− 143.4	− 58.5	16.04	16.82	22762.647	0.6299539	
12	+ 409.5	+187.5	16.05	16.91	22789.497	0.6125863	
13	+ 462.0	−299.7	15.87	17.03	22789.533	0.6274465	
14	+ 354.6	−207.0	15.88	17.00	22790.490	0.5454024	
15	+ 248.4	+228.0	16.39	16.67	23113.458	0.308724	
16	− 136.5	−202.5	16.43	16.90	22790.520	0.3031707	
17	− 214.5	+114.0	16.29	16.80	22762.612	0.3814992	
18	− 96.0	+ 12.6	15.83	16.42			
19	+ 165.6	− 42.0	16.34	16.85	22789.465	0.3918418	
20	+ 188.4	−351.6	16.32	16.81	23113.615	0.3844312	per. var.
21	+ 437.4	− 27.0	16.32	16.81	22790.410	0.3384650	
22	− 53.4	−288.0	16.56	16.85	var?		
23	+ 96.0	− 89.7	16.34	16.88	23113.460	0.3658077	per. var.
24	− 118.5	− 29.2	15.71	16.43		3.?	
25	+ 130.3	+ 31.7	16.16	16.90	22787.552	0.7051762	
26	− 288.0	−279.9	16.29	16.74	22789.485	0.3911185	
27	− 203.8	−157.9	16.16	16.93	22790.376	0.6710576	
28	− 181.4	+459.0	15.78	16.94	22790.500	0.6327877	
29	+ 125.4	− 79.5	16.56	17.04	22808.33	0.823239	
30	+ 57.7	−482.8	16.18	17.04	22790.47	0.5354938	
31	+ 60.6	− 0.1					
32	− 111.9	− 86.6	16.26	16.65	22790.475	0.3901324	
33	− 165.0	+ 12.2	16.58	17.14			
34	− 144.0	−216.7	16.48	16.70	not var.		
35	+ 104.1	+153.2	16.38	16.88	22789.480	0.3726736	
36	+ 120.3	+306.5	16.33	16.71	23113.698	0.3732511	per. var.
37	− 44.0	+ 62.2	15.68	16.48			
38	+ 21.3	−143.2	16.08	16.81	22789.483	0.7057825	
39	− 234.0	+212.5	16.84	17.26	not var.		
40	+ 8.9	+111.5	16.55	16.89	26418.664	0.3148076	
41	+ 19	+ 66					
42	− 67	+ 17	15.54	16.33			
43	− 34	+ 53					
44	+ 53	− 2	15.20	15.99			
45	− 5	− 36					
46	− 12	+ 34					

Refs. 51, 58, 79, 92, 97, 132, 160. Prints in 51, 92, 160.

CATALOGUE—*Continued*

NGC 5053 α 13^h 13^m.9, δ +17° 57′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	− 380	+158	15.80	16.60	30519.640	0.647178	
2	− 193	− 3	16.00	16.50	30556.611	0.378953	
3	+ 140	+138	15.90	16.55	30519.640	0.592946	
4	+ 31	−114	15.75	16.55	31969.580	0.667061	
5	+ 220	−220	15.90	16.45	29786.690	0.714861	
6	+ 126	+ 77	16.00	16.45	30555.617	0.292199	
7	− 87	+169	16.05	16.40	30880.610	0.351581	
8	+ 117	+ 50	16.05	16.55	31203.460	0.362842	
9	− 199	+382	15.95	16.55	31911.500	0.741741	
10	+ 94	+ 56	16.10	16.45	30883.640	0.437397	

Refs. 83, 158, 168. Prints in 83, 168.

NGC 5139 (ω Centauri) α 13^h 23^m.8, δ −47° 13′ (corrected position)

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	− 416.16	+298.89	10.7	12.6		58.7027	
2	− 340.00	+238.51	]13.06	16.12		484.	
3	− 507.93	+167.43	14.19	15.11	26524.245	0.8412205	
4	− 337.61	+262.10	13.89	15.18	26473.374	0.6273172	
5	− 282.75	+328.29	14.06	15.34	26460.409	0.5152828	
6	− 162.43	+252.95	13.84	15.24		irr.	
7	+ 153.19	+879.15	13.98	15.11	26470.425	0.7130181	
8	+ 629.43	+ 16.20	13.90	15.29	26472.238	0.5212846	
9	− 473.17	+137.14	14.35	15.32	26453.421	0.5233358†	
10	− 397.76	+244.48	14.38	14.90	26524.241	0.374950	
11	− 158.63	+338.73	14.3	15.0	irr.	0.56481	
12	− 193.16	+274.34	14.43	14.95	26469.446	0.3867486	
13	− 487.26	+199.54	13.98	15.12	26438.457	0.6690480	
14	− 473.51	−627.56	14.40	15.01	26472.456	0.3771799	
15	− 194.09	+242.62	14.13	14.98	26469.427	0.8106198	
16	+ 517.05	−536.81	14.38	14.95	26435.488	0.3301694	
17	+ 522.24	+200.00	14.18	14.61		60:	irr.
18	+ 596.64	+220.15	13.89	15.18	26454.408	0.6216682	
19	+ 444.14	+ 32.44	14.68	15.22	26434.540	0.2995533	
20	+ 280.88	+ 32.06	14.01	15.20	26469.388	0.6155547†	
21	− 355.75	+162.07	14.20	14.81	26469.257	0.3808180	
22	+ 552.18	−330.22	14.43	14.97	irr.	0.39609	
23	+ 2.54	+240.71	14.26	15.39	26470.392	0.5108651	
24	+ 524.71	−336.96	14.41	14.88	26468.520	0.4622108	
25	− 210.77	+ 17.48	13.98	15.07	26469.433	0.5885005	
26	− 229.58	+101.21	14.36	15.06	26459.469	0.7847199†	
27	− 205.47	+ 24.11	14.50	15.19	26471.386	0.6156764	
28			not var.				
29	− 193.25	− 6.45	12.44	13.50	26465.88	14.72429	
30	− 307.92	− 75.01	14.40	14.86	irr.	0.40448†	
31			not var.				
32	+ 174.39	+420.01	13.87	15.20	26469.421	0.6204317	

CATALOGUE—*Continued*

NGC 5139

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
33	− 554.54	− 24.00	13.88	15.24	26461.436	0.6023262	
34	− 396.87	−269.04	14.18	15.13	26471.369	0.7339450	
35	+ 71.70	+365.07	14.37	14.94	26468.484	0.3868382	
36	+ 246.11	+789.42	14.38	14.93	irr.	0.37984†	
37			not var.				
38	+ 169.10	−470.37	14.36	15.11	26469.456	0.7790480	
39	+ 741.86	−365.80	14.33	14.99	26469.474	0.3933567	
40	− 220.99	−125.30	13.95	15.15	26471.364	0.6340969†	
41	+ 151.80	−142.18	14.03	15.06	26523.185	0.6629590	
42	+ 0.21	− 50.21	12.5	14.9		149.4	
43	− 119.23	+103.16	13.41	14.55	26470.385	1.1568183	
44	− 243.40	−354.05	14.24	15.36	26466.380	0.5675440	
45	− 764.48	+ 80.97	13.94	15.19	26473.404	0.5891259	
46	− 770.61	+170.11	14.03	15.17	26454.471	0.6869382	
47	− 504.32	+269.26	14.27	14.73	irr.	0.48517†	
48	− 86.54	−104.54	13.09	13.95	26523.70	4.474293	
49	− 391.98	−553.77	14.16	15.28	26470.407	0.6046505	
50	− 530.75	+ 65.40	14.57	15.10	26472.336	0.3861815	
51	− 36.85	+258.73	13.86	15.16	26441.448	0.5741359	
52	− 112.85	+ 36.47	13.60	14.22	26461.348	0.6603737	
53	− 482.79	−447.74	13.30	13.87		87:	irr.
54	− 229.39	+592.76	14.22	15.05	26472.412	0.7728973	
55	− 617.73	−816.68	14.38	15.39	26471.323	0.5816930	
56	− 515.93	−541.96	14.37	15.38	26428.437	0.5680030	
57	+ 635.72	−493.26	14.31	15.06	26471.342	0.7944118	
58	− 335.44	+277.68	14.49	14.74	26524.233	0.3699057	
59	− 282.90	− 65.84	14.20	15.18	26523.231	0.5185176†	
60	− 108.42	−247.33	13.32	14.48	26473.513	1.349464	
61	+ 280.44	+ 68.07	13.72	14.48	26468.345	2.273582	
62	− 199.80	+ 45.28	13.88	15.10	26424.515	0.6197937	
63	− 996.82	−491.46	14.47	15.04	26438.567	0.8259507	
64	− 448.01	−457.49	14.45	15.02	26466.410	0.3444512	
65	− 454.49	−474.32	14.77	15.22	26523.238	0.06272282	
66	− 133.37	+375.15	14.46	14.95	irr.	0.40745†	
67	− 178.11	+593.57	14.18	15.28	26470.377	0.5644551	
68	− 338.18	+545.12	14.15	14.67	26469.366	0.5344773	
69	− 965.76	−530.94	14.10	15.25	26438.468	0.6532165	
70	+ 417.83	−304.65	14.45	14.94	26524.219	0.3906091	
71	+ 220.39	+ 47.13	14.38	14.92	26523.271	0.3574826	
72	+ 477.85	+734.87	14.42	14.94	26471.459	0.3845163	
73	− 532.49	+750.76	13.87	15.18	26472.358	0.5752184	
74	+ 215.47	+664.83	13.75	15.24	26454.399	0.5032505	
75	+ 341.44	+591.55	14.42	14.87	26456.501	0.4222508	
76	+ 113.31	+511.81	14.40	14.82	26523.135	0.3378438	

CATALOGUE—*Continued*

NGC 5139

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
77	+ 352.29	+392.42	14.45	14.93	irr.	0.42593†	
78	+ 586.10	+146.68	14.17	14.84	27943.307	1.1681179	
79	+1000.12	− 51.02	13.97	15.27	26456.423	0.6082747	
80	+1304:	−108:	14.1:	14.8		0.45 or 0.31	
81	+ 511.36	+228.72	14.46	14.98	26523.110	0.3894022	
82	+ 499.94	+126.98	14.43	14.96	26463.452	0.3358520	
83	+ 226.09	+424.66	14.43	15.00	26471.427	0.3566071	
84	−1202.81	− 74.70	14.09	14.90	26472.382	0.5798722	
85	−1010.51	+307.98	14.23	15.09	26523.243	0.7427555	
86	+ 293.14	+147.26	13.96	15.18	26470.383	0.6478442	
87	+ 113.68	+184.13	14.40	14.90	26454.448	0.3965019	
88	+ 98.13	+203.28	14.01	14.81	26523.273	0.6901992	
89	− 2.95	+159.29	14.47	14.97	26523.329	0.3748505	
90	− 5.30	+137.09	13.81	14.73	26460.432	0.6034020	
91	+ 43.72	+144.35	14.25	14.91	26459.480	0.8951422	
92	− 317.86	+446.38	14.10	14.58	26473.345	1.3450659	
93			not var.				
94	− 504.09	+355.09	14.64	14.95	26463.416	0.2539318	
95	− 824.80	− 11.05	14.49	14.98	26473.448	0.4049213	
96	− 71.20	+ 97.06	13.93	14.82	26455.467	0.6245312	
97	+ 225.50	+187.93	14.11	15.16	26523.234	0.6918869	
98	+ 198.25	+102.38	14.57	15.09	26524.265	0.2805657	
99	+ 160.35	+ 50.36	13.77	14.90	26472.390	0.7660839	
100	+ 179.49	+ 65.68	14.05	15.05	26434.489	0.5527119	
101	+ 444.11	− 73.28	14.50	14.94	26523.291	0.3408843	
102	+ 361.83	− 94.10	14.16	15.22	26468.445	0.6913841	
103	+ 283.14	+ 2.35	14.46	14.80	26456.354	0.3288461	
104	+ 822.98	−309.01	14.54	14.95	26471.370	0.8678506	
105	+ 603.23	−246.92	14.57	15.12	26524.300	0.3353375	
106	+ 130.35	+ 26.92	13.88	15.02	26523.189	0.5699074	
107	+ 279.83	−139.13	14.07	15.39	26466.424	0.5141010	
108	+ 185.66	− 46.36	13.84	14.81	26472.360	0.5944533	
109	+ 153.91	− 57.13	13.99	15.03	26469.395	0.7440653	
110	+ 158.94	− 87.08	14.41	14.96	26524.256	0.3221021	
111	+ 27.26	− 0.30	14.18	14.80	26438.498	0.7628923	
112	+ 79.83	−103.36	13.92	14.92	26470.380	0.4743558	
113	+ 99.99	−187.65	13.94	15.22	26523.244	0.5733636	
114	+ 38.08	−101.15	14.00	14.75	26470.416	0.6753065	
115	− 345.49	−336.14	14.03	15.21	26467.406	0.6304590	
116	− 109.66	+ 33.71	14.12	14.77	26472.437	0.7201327	
117	− 267.73	− 40.22	14.40	14.92	26456.506	0.4216653	
118	− 58.87	− 98.67	13.88	15.02	26473.380	0.6116200	
119	− 82.04	−157.45	14.51	14.83	26472.319	0.3058774	
120	− 211.29	−247.61	14.26	15.23	26523.264	0.5485722	
121	− 184.36	−189.58	14.48	14.81	26524.259	0.3041814	

CATALOGUE—*Continued*

NGC 5139

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
122	− 162.92	−261.41	13.99	15.17	26437.512	0.6349307†	
123	+ 46.11	−512.55	14.41	14.90	26473.331	0.4739051	
124	+ 78.88	−626.81	14.37	14.97	26524.107	0.3318614	
125	+ 23.74	−742.59	13.87	15.29	26471.408	0.5928902	
126	+ 822.95	−730.44	14.45	14.97	26453.493	0.3418933	
127	− 880.16	+ 4.31	14.54	14.92	26524.177	0.3052752	
128	− 289.77	− 92.09	14.25	14.86	26469.401	0.8349748	
129	+ 192.02	− 25.83	14.18	14.74			irr.?
130	− 366.17	+900.99	14.30	15.40	irr.	0.4932377	
131	− 165.05	− 59.95	14.40	14.86	26523.329	0.3921392	
132	− 72.44	− 29.31	13.97	14.96	26469.386	0.6556410	
133	−1914.22	+1053.78	13.74	14.53	26473.334	0.31709628	W UMa
134	− 942.87	+972.72	13.93	15.20	26466.386	0.6529039	
135	− 184.88	− 37.25	13.87	14.85	26470.314	0.6325795	
136	− 154.26	+ 60.08	14.22	14.64	26472.409	0.3919136	
137	− 149.54	+ 96.23	14.38	14.90	26473.286	0.3342134	
138	− 111.12	−187.55	12.5	13.6		74.6	irr.
139	− 86.94	+ 65.18	14.00	14.90	26462.404	0.6768666	
140	− 42.65	− 86.80				short	
141	− 55.47	− 47.46	14.05	14.75	irr.	0.6975651	
142	− 37.35	− 2.56	14.2	14.8		short	
143	− 37.45	+ 71.40	14.24	14.77	26470.394	0.8207020	
144	− 33.28	+ 22.44	14.33	14.81	26454.329	0.8353054	
145	+ 49.07	−148.51	14.40	14.87	irr.	0.37315†	
146	+ 65.96	− 48.03	13.87	14.77	26469.386	0.6331021	
147	+ 298.70	−151.04	14.35	14.80	26473.333	0.4226945	
148	+ 299.20	+ 44.21	12.9	13.8		90:	irr.
149	+ 477.33	+894.18	13.92	15.13	26523.256	0.6827332	
150	+ 543.18	−442.23	14.07	14.94	26462.387	0.8991585	
151	+1010.06	+753.35	14.42	14.84	26523.333	0.4077805	
152	+ 13.84	− 48.83	12.8	13.7		124:	irr.
153	+ 34.46	+136.32	14.48	14.88	26524.176	0.3864509	
154	+ 169.59	−113.20	14.55	14.72	26524.165	0.3223311	
155	+ 75.25	+237.31	14.43	14.88	26473.344	0.4139117	
156	+ 15.06	−191.94	14.41	14.83	26468.432	0.3591887	
157	+ 1.77	+ 82.58	14.42	14.79	26523.370	0.4064970	
158	− 10.58	−119.80	14.32	14.74	26472.442	0.3673350	
159	−2039.94	−891.45	14.39	14.96	27565.332	0.3431150	
160	− 711.13	+969.21	14.46	14.98	26473.439	0.3972932	
161	− 96.81	−129.27	13.3	13.8		irr.	
162	− 392.40	−252.39	12.9	13.6		irr.	
163	− 575.24	+499.91	14.51	14.78	26472.451	0.3132294	
164	+ 152.75	+478.38	13.7	14.0		irr.	prob. red
165	− 69.92	+104.59					

CATALOGUE—*Continued*

NGC 5139

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
166	− 2.89	+144.71					
167	− 352.63	−321.43					
168	− 543.66	−201.42	14.96	15.46		0.3212933	

So many of the RR Lyrae variables in this cluster have been shown to be variable in period or form of light curve that this information cannot be included in the table. For further particulars see especially Martin, ref. 118, and Wright, ref. 136.

†Two periods given by Martin.

Variables Nos. 28, 31, 37, 93 are said by Bailey to be not variable.

Epochs of maximum from ref. D.

Refs. 14, 17, 20, 31, 40, 62, 67, 90, 99, 113, 116, 118, 119, 129, 131, 136, 143, 162, 165. Plates in 20 and 118.

NGC 5272 (Messier 3) α 13^h 39^m.9, δ +28° 38′

1	− 5.2	−128.5	14.80	16.14	15021.378	0.5206324	765
2	+ 15.8	+ 52.6					894
3	+ 57.9	− 66.0	14.91	16.16	15021.225	0.558207	none
4	− 43.5	− 8.8	14.9	16.0			559
5	+ 261.0	− 22.3	14.76	16.09	15021.239	0.505894	1357
6	− 123.9	+ 60.1	14.75	16.19	15021.452	0.5143207	361
7	− 4.8	+ 87.2	14.69	16.25	15021.064	0.4974290	775
8	− 81.7	− 23.4	not var.				437
9	− 291.4	−207.8	14.84	16.22	15021.111	0.5415672	226
10	+ 153.6	+138.0	15.03	16.17	15021.270	0.5695127	1291
11	− 152.6	−209.7	14.89	16.22	15021.131	0.5078919	321
12	− 3.8	−145.4	15.35	15.98	15021.015	0.3178890	776
13	− 26.0	−137.5	15.08	16.14	15021.323	0.4830535	644
14	− 49.0	−161.0	15.01	16.10	15021.179	0.6358993	537
15	− 90.8	−273.2	14.83	16.24	15021.299	0.5300771	411
16	− 301.4	− 93.1	14.73	16.24	15021.418	0.5115072	221
17	+ 142.4	−440.4	15.24	16.37	15021.265	0.5761344	none
18	+ 97.6	−295.3	15.08	16.34	15021.142	0.5163462	1202
19	+ 350.5	−245.6	15.64	16.20		0.631981	1388
20	+ 333.5	−271.6	14.74	16.13	15021.289	0.4912607	1380
21	+ 346.9	+ 17.9	14.88	16.29	15021.171	0.5157298	1386
22	+ 190.2	− 10.7	14.83	16.25	15021.200	0.481466	1320
23	− 113.0	+279.2	14.79	15.70	15021.082	0.5953756	374
24	− 147.6	+ 10.4	15.07	16.09	15021.563	0.6633499	328
25	− 124.4	− 31.4	14.77	16.23	15021.089	0.480048	362
26	− 177.4	− 43.0	14.89	16.15	15021.239	0.5977479	296
27	− 110.2	−102.8	15.17	16.21	15021.566	0.5790981	379
28	− 25.0	−105.8	15.03	16.28	24290.335	0.470666	656
29	− 65.2	− 73.6					486
30	− 36.5	+ 58.0	14.88	16.19	22760.635	0.5120891	593

CATALOGUE—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
31	+ 33.1	+ 65.1	14.73	16.25	15021.542	0.5807218	982
32	+ 11.8	+ 60.1	14.86	16.38	15021.108	0.4953526	867
33	+ 70.5	− 89.0	15.01	16.22	15021.217	0.5252255	1126
34	+ 135.4	+170.2	14.89	16.16	15021.136	0.5591078	1265
35	− 107.3	−278.2	15.04	16.24	15021.032	0.530608	384
36	+ 172.0	− 35.4	14.86	16.26	15021.272	0.5455861	1308
37	− 236.7	+164.7	15.14	16.02	15021.248	0.3266402	253
38	− 203.0	+127.7	15.06	16.26	24290.304	0.5580326	279
39	− 243.6	+121.4	15.07	16.17	15021.073	0.5870732	249
40	− 271.2	+112.4	14.93	16.18	15021.609	0.5515419	234
41	− 93.3	+ 54.0	15.04	16.21	15021.441	0.4850291	407
42	− 78.6	+ 41.0	14.85	16.27	15021.515	0.5902069	445
43	+ 99.9	+ 24.7	14.86	16.23	15021.191	0.5405023	1207
44	+ 170.0	+ 99.4	14.75	16.21	15021.368	0.506443	1307
45	− 241.2	−129.9	14.93	16.30	15021.349	0.5368966	252
46	− 128.1	− 51.5	15.46	16.24	15021.264	0.613367	355
47	− 117.5	− 73.2	14.98	16.20	15021.459	0.5410201	366
48	+ 126.9	−102.7	15.16	15.99	15021.088	0.6278087	1253
49	+ 140.0	−100.7	15.19	16.23	15021.266	0.5482222	1268
50	+ 8.8	−234.0	15.15	16.09	15021.327	0.513088	840
51	+ 30.8	−226.4	15.08	16.21	15021.486	0.5839856	965
52	− 76.8	+152.0	14.99	16.16	15021.485	0.516189	451
53	− 7.4	+122.8	14.70	16.13	15021.006	0.5048891	759
54	− 32.6	+106.4	14.94	16.22	15021.193	0.506493	616
55	− 204.2	+324.4	14.85	16.21	15021.699	0.5298114	278
56	− 141.1	+358.6	15.20	15.94	22760.623	0.3295969	338
57	+ 155.2	− 0.2	14.97	16.22	15021.618	0.5122311	1292
58	− 86.2	+ 46.2	14.78	16.16	22760.621	0.517101	425
59	− 109.8	−228.4	15.22	16.24	15021.332	0.5888026	378
60	− 297.4	−315.4	15.20	16.14	15021.389	0.7077216	222
61	+ 190.2	+363.0	14.88	16.20	15021.076	0.5209367	1321
62	+ 90.2	+417.0	15.21	16.10	15021.331	0.6524063	1187
63	+ 37.2	+341.9	14.93	16.14	15021.094	0.5704204	999
64	+ 114.8	+330.4	15.05	16.10	15021.324	0.6054592	1234
65	+ 125.4	+327.5	14.74	16.09	15021.503	0.6683397	1250
66	− 101.4	+121.4	15.20	16.01	15021.323	0.6201973	396
67	− 131.4	+123.0	15.21	16.12	15021.411	0.5683681	351
68	+ 21.9	+174.8	14.8	16.3		0.355974	922
69	+ 80.6	+141.0	15.09	16.18	15021.553	0.5665806	1164
70	+ 37.6	+152.2	15.12	15.70	15021.315	0.486064	1003
71	+ 160.6	− 2.0	15.12	16.20	15021.168	0.5490517	1298
72	+ 445.5	− 2.2	14.61	16.37	15021.327	0.4560721	1409
73	+ 438.5	+ 62.2	15.0	16.0			1406
74	+ 88.2	+151.0	14.87	16.26	15021.452	0.4921415	1181
75	+ 49.0	+159.5	15.23	15.99	15021.411	0.3140813	1057
76	− 14.4	− 88.2	14.72	16.41	15021.293	0.5017529	710
77	− 94.4	+ 27.8	14.85	16.36	15021.451	0.4593422	404

CATALOGUE—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
78	+ 47.5	+ 66.4	15.10	16.13	15021.249	0.6119228	1051
79	+ 43.4	+349.4	14.81	16.24	15021.229	0.4832979	1041
80	+ 416.8	+284.6	15.05	16.27	15021.433	0.5385169	1400
81	+ 342.8	+351.1	14.67	16.28	15021.325	0.5291108	1384
82	− 102.6	−601.8	14.92	16.27	15021.527	0.5245027	391
83	− 441.6	+113.4	14.66	16.25	15021.046	0.5012423	181
84	+ 64.0	+165.2	15.20	16.14	15021.248	0.5957289	1105
85	+ 306.2	+225.8	15.00	15.83	22760.517	0.355820	1373
86	+ 513.0	−114.2	15.31	16.13	15021.016	0.2926615	1422
87	+ 110.6	+ 60.2	15.31	15.91	22760.535	0.357480	1222
88	− 35.0	− 70.2	14.9	16.0	24290.324	0.298519	597
89	+ 28.0	−110.8	14.86	16.15	15021.507	0.5484778	948
90	+ 97.2	−188.2	14.80	16.24	15021.461	0.5170344	1201
91	− 14.3	−550.0	15.05	16.27	15021.259	0.5301710	713
92	− 29.0	−408.4	14.88	16.23	15021.083	0.5035579	623
93	− 319.4	−396.6	15.30	16.22	15021.177	0.6023041	214
94	− 488.4	−224.6	14.84	16.21	15021.118	0.5236921	173
95	− 154.7	+ 15.4	13.73	14.42		103.19	318
96	− 164.2	−234.0	14.78	16.13	15021.019	0.4994538	305
97	− 130.0	−196.7	15.53	16.01	15021.524	0.334927	353
98	+ 132.4	− 3.2	not var.				1259
99	+ 201.8	− 55.0	14.8	15.8			1330
100	+ 69.9	+ 97.3	15.3	16.2		0.618813	1122
101	+ 46.4	+ 83.7	15.50	16.14	15021.101	0.643900	1048
102	+ 58.4	+114.9	15.2	15.9	variable?		1090
103	+ 58.1	+120.4	not var.				none
104	− 25.8	+145.5	14.74	16.09	15021.288	0.5699246	650
105	− 20.9	+191.6	15.17	15.66	15021.315	0.2877445	679
106	− 48.0	+168.0	15.17	16.20	15021.310	0.5471636	541
107	− 75.8	+335.0	15.02	15.99	15021.443	0.3090344	455
108	− 219.0	+310.9	14.77	16.21	15021.083	0.5196047	264
109	− 89.3	+ 2.7	14.86	16.31	15021.033	0.5339259	416
110	− 99.4	− 15.8	15.02	16.24	15021.397	0.5353700	397
111	− 92.7	+ 21.9	14.96	16.18	15021.402	0.5101921	409
112	− 144.6	−719.4	not var.				333
113	+ 199.8	−689.8	14.90	16.43	15021.241	0.5130031	1328
114	+ 11.8	+622.0	15.08	16.24	15021.515	0.5977254	873
115	+ 445.0	+664.7	14.69	16.25	15021.297	0.5133533	1410
116	− 491.8	+465.2	14.80	16.22	15021.441	0.5148090	170
117	+ 89.6	−467.6	15.26	16.23	15021.579	0.6005122	1184
118	+ 144.4	−292.2	14.73	16.28	15021.272	0.4993795	1277
119	+ 253.4	+106.2	14.73	16.16	15021.460	0.5177510	1353
120	− 295.8	+231.4	15.36	16.05	15021.284	0.6401377	223
121	− 43.6	+ 56.1	15.41	16.25	22760.550	0.5351935	561
122	− 33.5	− 46.4	14.6	16.1		0.5017	608
123	− 259.	−985.	15.16	16.75	15021.395	0.5454416	244
124	− 66.4	−201.4	15.3	16.2		0.752438	479

CATALOGUE—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
125	+ 186.3	−132.8	15.41	16.08	15021.029	0.3498210	1317
126	− 15.4	−146.4	15.50	16.03	15021.208	0.3484044	700
127	+ 95.6	− 63.6	not var.				1198
128	+ 114.6	+131.4	15.07	15.97		0.2922661	1231
129	− 43.6	+ 77.2	15.2	16.1		0.305471	560
130	+ 4.2	+ 84.6	15.10	16.13	22760.347	0.5688389	818
131	− 73.2	+ 27.4	15.18	15.94	15021.318	0.2976902	459
132	− 53.6	− 22.0	15.3	16.4	24290.387	0.3398479	524
133	− 58.6	+ 43.5	14.89	15.96	15021.482	0.5507230	503
134	− 22.4	+ 52.4	14.9	16.3	24290.282	0.6190	669
135	− 27.0	+ 38.0	15.0	16.5		0.56843	636
136	− 25.4	+ 33.4	15.6	16.2			643
137	+ 53.0	− 18.8	14.9	16.2	15021.155	0.575146	1072
138	− 263.6	+ 41.9	not var.				238
139	+ 34.5	+ 28.0	15.25	16.12	22760.465	0.560004	985
140	− 15.7	+108.9	15.10	15.88	22760.216	0.3331259	708
141	−1497.5	−249.9	14.9	16.4		0.2695477	48
142	− 30	− 59	15.6	16.6	24290.397	0.568627	620
143	− 34	+ 16	15.4	16.4	24290.337	0.51111	604
144	+ 54	−100	14.8	16.7	24290.565	0.59674	
145	+ 29	+ 8	14.9	16.5	24290.528	0.514456	944?
146	+ 96	− 59	14.6	16.5	24290.563	0.596740	1193?
147	− 21	+ 46	15.1	16.3	24290.005	0.34644	671
148	− 7	+ 37	15.3	16.4	24290.170	0.467246	755
149	+ 34	+ 52	14.7	16.5	24290.228	0.54985	
150	+ 69	+ 37	14.8	16.7	24290.359	0.52397	1119
151	+ 4	− 40	14.9	16.3	24290.191	0.51705	
152	+ 77	+ 50	15.0	16.3	24290.355	0.32641	1151?
153	− 38	+ 60	not var.				585
154	+ 2	− 29	12.9	14.0	24647:	15.7677	801
155	− 64	− 74					486
156	− 21	− 42	not var.				678
157	− 17	+ 35	14.2	15.7	24647.650:	0.5283	698
158	− 16	− 41	15.2	16.5	24647.564:	0.50809?	703
159	− 15	+ 16	14.9	16.6	24647.602:	0.5337	714
160	− 9	− 44	14.9	16.1	24647.446	0.64792	742
161	+ 17	− 58	15.4	16.4	24647.567:	0.49874	901
162	+ 28	− 32	not var.				950
163	− 16	− 32	not var.				702
164	+ 21	− 36	15.3	15.9			909
165	+ 73	+ 20	14.7	16.5	24647.544	0.483638	
166	− 97	− 8	15.1	16.2			402
167	− 78	− 37	15.4	16.5	24647.448	0.69245	447
168	− 45	+ 7	14.9	16.0	24647.617	0.3770	553
169	− 29	− 35	not var.				627

CATALOGUE—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
170	− 28	+ 32	15.1	16.1	24647.716:	0.43725	633
171	− 27	+ 16	15.0	16.1	24647.864	0.4303	638
172	− 21	+ 25	14.9	16.5	24647.700	0.59400	677
173	− 13	+ 39	15.2	16.6	24647.670:	0.606990	
174	− 9	− 34	15.1	16.1	24647.710	0.4082	743
175	+ 42	+ 26	14.9	16.2	24647.914	0.60780	
176	+ 46	+ 32	14.8	16.4	24647.621	0.55599	
177	+ 63	− 29	15.0	16.3	24647.953	0.34835	1102
178	+ 79	+ 46	15.2	16.5	24647.755	0.26499	1153
179	+ 39	−774	not var.				
180	− 19	− 27	not var.				676?
181	− 30	− 14	not var.				
182	− 19	+ 60	not var.				
183	+ 29	+ 7	not var.				944?
184	− 25	− 14	14.9	16.4	24647.841	0.517	645?
185	− 15	+ 32	15.2	16.1			705?
186	+ 12	− 64	15.1	16.1	24647.670	0.675	
187	− 23	+ 9	14.9	16.2	24647.961	0.3927	
188	− 27	+ 24	15.0	16.0	24647.615:	0.3677	641?
189	− 25	− 21	15.2	16.0	24647.964	0.668	654
190	− 8	+ 28	14.8	16.5	24647.936	0.501	749
191	0	+ 24	15.1	16.1	24647.981	0.512	802
192	− 2	+ 3	15.0	16.1	24647.933:	0.525	783
193	+ 15	− 7	14.8	16.3	24647.777	0.630	881
194	+ 17	− 13	15.1	16.4	24647.758	0.549	892
195	− 13	− 29	15.0	16.2	24647.470:	0.600	720
196	+ 47	+ 1					1052
197	+ 58	+ 10	15.1	16.5	24647.689	0.500075	1092
198	− 23	+ 15	15.2	16.0	24647.923:	0.3617	666
199	− 19	+ 13	14.8	16.3	24647.699:	0.488	
200	− 4	+ 21					769
201	+ 4	− 9					none
202	− 379.7	+101	15.4	15.8			190
203	− 30.2	−308	15.56	15.72		0.28719	632
204	− 106.4	− 18	15.76	15.90		0.9170	390

Refs. 1, 8, 10, 11, 14, 17, 19, 20, 22, 25, 28, 31, 32, 38, 40, 43, 45, 50, 55, 56, 60a, 61, 76, 80a, 84, 86, 98, 101, 105, 109, 110, 111, 115, 130, 135, 141, 144, 165, 179, M. Plates in 20, 25.

Sandage and Roberts (ref. M) strongly suspect v.Z. 329 is variable with small amplitude, 0.15, and hope other observers will try to corroborate this.

Just as for NGC 5139, most of the variables have been shown to have period changes, see especially Martin, ref. 144 and Hett, ref. 141. These cannot be included in the table. The value given for the period is usually from the latest work on the star.

The data for this cluster have been combined from many sources as follows: Positions: Nos. 1–137 Bailey, 138–141 Larink, 142–183 Müller, 184–199 Greenstein, 200–201 Shapley. Magnitudes from Greenstein. Epochs: 1–153 from Müller, 154–199 Greenstein, data on No. 202 from Schwarzschild, Nos. 203 and 204 from Sandage, with von Zeipel's positions.

CATALOGUE—*Continued*

NGC 5272

In a further attempt to clear up some of the confusion of identification of the variables in this cluster (discussed in detail in the last catalogue), I have identified as far as possible the variables with the numbers in von Zeipel's catalogue (*Ann. l'Obs. Imp. Paris, Mém.*, v. 25, F 1–101, 1908). In cases where the variable is definitely not in the catalogue, this is indicated by "none" in the number column. Where no satisfactory identification has been made, a blank is left; and the number is questioned if doubt exists.

There is doubt as to whether vars. 145 and 183 correspond to v.Z. 944 or 961. Shapley's Variable 18 is definitely v.Z. 944; but it is not certain whether his Var. 18 is the same as either 145 or 183.

NGC 5286 α 13^h 43^m.0, δ −51° 07′

No variables found. Ref. 71. No map.

NGC 5466 α 14^h 03^m.2, δ +28° 46′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+858	− 95	15.6	16.7	30553.674	0.577415	
2	− 62	−110	15.5	16.6	30554.720	0.588523	64
3	− 31	− 8	15.4	16.7	30550.623	0.578065	95
4	− 80	+ 9	15.5	16.6	30556.602	0.337968	56
5	− 64	+112	15.7	16.7	30519.697	0.380519	61
6	+122	− 24	15.2	16.6	29786.653	0.62096	202
7	−210	−225	15.7	16.7	30519.697	0.703423	20
8	+ 23	− 6	15.8	16.7	30520.617	0.629120	141
9	+ 31	+ 15	15.5	16.7	30170.656	0.685027	148
10	+ 85	+ 46	15.8	16.7	30519.697	0.709273	186
11	+117	+ 68	15.7	16.7	30884.625	0.37799	198
12	+ 17	− 88	16.0	16.5	30880.665	0.2942387	134
13	− 49	− 73	16.0	16.7	30556.702	0.341557	83
14	− 47	+ 52	15.8	16.5	30880.599	0.440041	84
15	+223	+ 20	15.9	16.5	30519.618	0.28672	227
16	−149	−175	16.0	16.5	30553.612	0.29667	37
17	− 60	− 30	15.9	16.4	30519.713	0.370117	68
18	+ 44	+ 41	16.0	16.7	30519.697	0.37406	166

No. is from Hopmann's Catalogue, *A.N.*, v. 229, p. 209, 1927.
Refs. 78, 79, 157. Prints in 78, 157.

NGC 5634 α 14^h 27^m.0, δ −05° 45′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	− 56.5	− 19.5	16.41	17.39		0.65872	
2	− 25.4	+ 83.1	16.19	17.38			
3	− 45.1	+ 41.9	16.48	17.47			
4	+ 54.2	− 65.2	16.55	17.39			
5	− 11.6	−162.9	16.72:	17.19			
6	+ 43.4	− 52.6	16.69	17.05:			
7	− 0.4	− 4.0					

Ref. 156, with plate.

CATALOGUE—*Continued*

NGC 5694 α 14^h 36^m.7, δ −26° 19′
No variables found. Ref. 104. No map.

Baade's Cluster α 15^h 13^m.5, δ +0° 4′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	− 97	+ 25	16.80	17.55			
2	− 85	−246	16.90	17.60			
3	+143	−166	16.95	17.50			
4	+ 35	−238	16.90	17.60			
5	− 84	+ 94	17.05	17.50			

5 suspected variables.
Ref. 176 with print.

NGC 5897 α 15^h 14^m.5, δ −20° 50′

No.	x″	y″	Max.	Min.
1	−109	−201	15.8	16.5
2	− 57	− 97	15.8	16.4
3	− 40	− 4	15.8	16.5
4	+ 71	+ 20	15.5	15.9

Ref. 187 with plate.

NGC 5904 (Messier 5) α 15^h 16^m.0, δ +02° 16′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 27.7	+161.1	14.31	15.41	27563.794	0.52178673	
2	−343.5	− 31.5	14.74	15.60	27601.700	0.526	
3	+160.1	+113.7	14.64	15.33	27567.842	0.60018398	
4	− 12.3	+ 73.8	14.65	15.89	27627.708	0.44963886	
5	− 7.8	+ 51.6	14.83	16.06	27567.929	0.545903	
6	+ 27.2	− 46.6	14.55	15.61	27567.856	0.54883108	
7	− 5.1	−191.3	14.42	15.57	27601.730	0.49439008	
8	+134.0	−133.2	14.55	15.58	27605.697	0.54622519	
9	+195.0	+ 88.0	14.68	15.50	27563.855	0.6988956	
10	+107.4	+382.0	14.43	15.77	27567.825	0.53066335	
11	−154.5	+ 84.5	14.43	15.58	27563.817	0.59589173	
12	−175.5	− 17.3	14.40	15.73	27601.762	0.46771968	
13	+ 11.0	− 65.4	14.75	15.64	27567.800	0.5131237	
14	−145.6	+103.7	14.28:	15.34:	27567.974	0.4872433	
15	+192.0	+ 3.6	14.84	15.32	27567.908	0.33676094	
16	+ 91.0	+ 83.9	14.29	15.53	27567.781	0.64762455	
17	− 26.1	+ 44.3	14.80	15.91	27567.723	0.601354	
18	+151.7	−107.7	14.83	15.39	27567.773	0.464	
19	+233.7	−129.9	14.11	15.68	27601.706	0.46995413	
20	−255.5	− 25.0	14.50	15.29	27601.729	0.6094760	
21	+322.6	+ 74.0	14.46	15.52	27605.684	0.6048946	
22	−205.7	+383.5	not var.				
23	−253.4	− 10.9	not var.				

CATALOGUE—*Continued*

NGC 5904

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
24	− 46.8	− 71.7	14.77	15.65	27567.821	0.47837785	
25	− 28.9	−128.0	13.83	14.73	27567.766	short	
26	+ 21.8	+101.5	14.42	15.46	27601.761	0.6225647	
27	− 6.7	− 59.2	14.37	15.74	27888.894	0.4703	
28	+132.2	−121.1	14.50	15.68	27540.882	0.54394489	
29	−374.7	− 76.6	14.56	15.52	27567.700	0.4514	
30	+ 22.8	−212.8	14.80	15.49	27567.761	0.5921760	
31	+151.7	−141.7	14.79	15.36	27567.872	0.30058294	
32	+201.9	−150.6	13.98	15.50	27605.754	0.45778653	
33	− 21.1	+127.5	14.24	15.55	27601.738	0.50147264	
34	+ 84.3	+ 59.5	14.65	15.52	27567.727	0.56814350	
35	− 12.2	−114.7	14.68	15.16	27567.866	0.30811974	
36	− 8.4	− 52.2	14.96	15.91	27563.868	0.6277	
37	+ 44.7	− 67.0	14.49	15.60	27605.762	0.48879470	
38	− 44.2	+117.2	14.49	15.90	27889.937	0.47042783	
39	−125.3	−205.2	14.23	15.61	27563.832	0.5890352	
40	+124.8	+113.5	14.83	15.26	27605.698	0.31732857	
41	+ 19.3	+231.4	14.23	15.64	27567.879	0.48857528	
42	−123.2	−120.8	11.20	12.24	27567.8	25.738	Sp.
43	−201.8	+154.3	14.82	15.48	27601.767	0.6602275	
44	−102.5	+ 31.1	14.97	15.33	27601.732	0.247?	
45	−116.7	+ 65.7	14.74	15.90	27567.774	0.61663546	
46	− 80.0	+ 69.1	not var.				
47	− 75.3	+ 58.1	14.84	15.96	27563.861	0.5397300	
48	− 62.5	+106.3	not var.				
49	+ 52.7	+177.5	not var.				
50	+ 38.0	+109.1	14.00:	14.54:		irr.?	Sp.
51	+ 0.3	+135.5	var?				
52	+107.9	+ 35.3	14.49	15.57	27563.804	0.50178498	
53	+ 68.9	+ 19.2	14.98	15.28	27601.70	0.37360	
54	+ 30.3	+ 57.2	14.62	15.68	27567.721	0.45410915	
55	+ 80.1	−163.2	14.87	15.26	27601.734	0.32889680	
56	− 68.9	+ 96.5	14.75	15.86	27889.931	0.53469099	
57	− 30.6	+ 99.7	14.94	15.43	27567.897	0.28467869	
58	− 605.1	+168.2	14.63	15.65	27601.716	0.491266	
59	− 150.0	− 35.5	14.42	15.33	27540.936	0.54202572	
60	− 109.7	+ 8.2	15.04	15.74	27567.75	0.285218?	
61	− 254.9	− 31.4	14.63	15.60	27567.826	0.56861702	
62	+ 166.8	−216.8	14.73	15.40	27601.704	0.281409	
63	+ 212.9	+ 51.8	14.25	15.57	27567.851	0.49767716	
64	− 51.2	−248.9	14.54	15.64	27540.853	0.5445076	
65	− 159.9	− 93.8	14.28	15.60	27628.729	0.48065810	
66	+ 218.3	+406.8	14.81	15.36	27567.813	0.35068	
67	−1028.2	− 59.8	14.83	15.30	27567.733	0.349046	

CATALOGUE—*Continued*

NGC 5904

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
68	+ 897.5	+ 47.6	14.80	15.33	27628.727	0.3342771	
69	+ 653.3	+751.6	14.80	15.72	27567.761	0.49487432	
70	+ 393.8	+626.4	14.55	15.63	27567.930	0.5585282	
71	+ 664.1	+290.3	14.45	15.70	27541.011	0.5024681	
72	+ 689.7	+ 38.3	14.53	15.57	27596.82	0.562	
73	+ 17.3	+604.7	14.63	15.31	27601.753	0.34011278	
74	+ 202.8	+162.8	14.18	15.46	27626.684	0.45399611	
75	+ 78.6	−412.8	14.66	15.42	27596.816	0.6854141	
76	+ 80.5	−309.2	14.73	15.18	27563.813	0.4324211	
77	− 171.5	−184.8	14.68	15.42	27605.721	0.8451134	
78	+ 65.5	+159.7	14.86	15.28	27567.727	0.26481742	
79	− 133.5	− 32.2	14.95	15.51	27567.884	0.33313840	
80	− 48.6	+111.6	15.05	15.54	27562.986	0.33654242	
81	− 72.2	−121.7	14.62	15.54	27567.972	0.5573241	
82	− 67.8	+ 12.4	14.86	15.72	27563.798	0.5584455	
83	− 84.7	− 87.8	14.80	15.66	27567.783	0.5533080	
84	+ 43.7	− 31.9	11.54	12.61	27602	26.5	Sp.
85	+ 38.3	− 34.4	14.80	15.70	27567.970	0.52741	
86	+ 34.6	− 33.0	14.50	15.83	27567.856	0.56733	
87	+ 122.0	− 1.8	14.84	15.21	27540.914	0.7383875	
88	+ 65.2	+ 61.8	15.08	15.48	27563.832	0.32808270	
89	+ 60.0	+ 64.7	14.79	15.69	27626.707	0.55844189	
90	− 44.7	+ 15.3	14.67	15.88	27540.828	0.5571534	
91	− 36.0	+ 35.0	15.04	15.96	27567.927	0.584944	
92	− 56.6	−123.5	14.28	15.58	27567.963	0.46358	
93	+ 44.0	− 35.7	14.54	15.81	27567.771	0.55231	
94	− 23.5	+ 17.4	15.26	16.11	27601.728	0.53141	
95	− 47.2	+102.8	15.13	15.80	27626.689	0.29082	
96	− 12.4	+ 32.9	14.96	16.15	27563.778	0.51225	
97	+ 48.9	− 92.5	14.18	15.61	27601.754	0.54466	
98	+ 37.3	+ 20.0	15.26	15.71	27605.737	0.30639	
99	+ 34.4	− 0.1	15.32	15.89	27567.739	0.32134	
100	+ 2.8	+ 48.7	15.30	16.01	27628.710	0.29434	
101	− 281.6	+ 36.0	17.15				SS Cyg?
102	+ 14.8	− 14.8					prob. RR Lyr
103	+ 20.5	− 8.8					prob. RR Lyr

Epochs from ref. K, unpublished.

Refs. 2, 3, 4, 5, 6, 7, 11, 12, 14, 15, 17, 20, 24, 26, 31, 33, 40. 42. 53, 54, 60, 82, 137, 165, K.
Plates in 20, 33, 137.

NGC 5986 α 15^h 42^m.8, δ −37° 37′

1 variable at a radial distance of 1′.7 from centre.

Refs. 14, 20. No map.

CATALOGUE—*Continued*

NGC 6093 (Messier 80) α 16^h 14^m.1, δ −22° 52′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	−137	+ 49	13.1	14.5	29406.8	15.70	Sp.
2	+ 22	− 19	14.7	15.3			
3	+104	+ 56	15.6	16.3			short per.
4	− 85	+ 61	15.6	16.2			short per.
5	+ 14	− 67	15.7	16.2			short per.
6	+520	+296	9.3	15.8	32036	177.13	S Sco
7	+502	+112	9.5	15.5	32142	222.53	R Sco
Nova	+ 4.0	+ 2.7	6.8		00551		T Sco

A suspected variable near this cluster is No. 101570 in Russian "Catalogue of Stars Probably Variable," 1951.

Refs. 20, 69, 122, 148, 165. Plates in 20, 148. Ref. 122 gives bibliography of nova.

NGC 6121 (Messier 4) α 16^h 20^m.6, δ −26° 24′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	−281	+ 42	13.46	13.97	29706.315	0.288872	
2	−248	−195	13.05	14.10	29676.448	0.5356817	
3	−208	−507	12.92	14.08	29723.221	0.506651	
4	−185	−340	11.0	12.5		semireg.	Sp.
5	−185	− 93	13.57	13.99	29522.035	0.622401	
6	−115	+318	13.54	14.09	29705.377	0.320504	
7	−113	+231	12.99	14.28	29748.231	0.4987743	
8	−110	+111	12.88	14.22	29676.458	0.5081753	
9	−104	+105	12.75	14.16	29676.332	0.5718921	
10	− 68	+159	12.68	14.18	29717.391	0.4907161	
11	− 64	−297	13.32	14.14	29496.021	0.4930763	
12	− 53	−207	13.04	14.38	29676.323	0.4461309	
13	− 47	+270	12.37	13.08			Sp.
14	− 47	−244	12.96	14.40	29717.295	0.4635292	
15	− 32	+436	12.98	14.25	29496.035	0.4437854	
16	− 29	+ 69	13.05	14.18	29705.381	0.5425452	
17	− 8	+ 20	13.40	13.74	29708.319	0.855469	
18	+ 4	+ 27	12.84	14.20	29676.446	0.4787915	
19	+ 11	+358	12.76	14.18	29511.075	0.4678119	
20	+ 13	− 63	13.24	13.60	29676.381	0.3094164	
21	+ 19	− 4	12.73	14.10	29705.436	0.471986	
22	+ 34	+ 80	13.40	13.98	29676.410	0.6030634	
23	+ 38	− 26	13.26	13.77	29676.389	0.2985478	
24	+ 49	+ 48	13.12	14.06	29676.450	0.5467733	
25	+ 70	+ 70	13.08	14.08	29723.276	0.6127352	
26	+ 94	− 72	12.80	14.14	29538.993	0.5412200	
27	+ 118	+255	12.90	14.09	29723.260	0.6120184	
28	+ 259	+ 84	12.60	14.02	29676.411	0.522322	
29	+ 326	+598	12.88	14.02	29705.367	0.5224857	
30	+ 340	− 69	13.29	13.87	29676.458	0.2697501	
31	+ 353	+ 45	12.72	14.03	29676.272	0.5053135	

CATALOGUE—*Continued*

NGC 6121

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
32	+ 746	− 40	12.98	13.96	29705.446	0.579109	
33	+ 805	+630	12.70	13.96	29676.340	0.6148277	
34	− 820	+416	13.16	14.36	29723.338	0.554843	
35	− 377	+ 62	13.44	14.15	29705.441	0.627042	
36	− 208	−259	13.26	14.18	29676.370	0.541310	
37	− 39	+ 2	13.46	13.76	29522.064	0.247352	
38	− 23	− 92	13.38	14.09	29496.053	0.577848	
39	+ 1	− 80	13.62	14.06	29676.463	0.623980	
40	+ 25	+ 49				0.40151	
41	+ 65	−150	13.53	13.97	29676.402	0.2517311	
42	+ 377	+558	13.33	13.78	29526.164	0.303708	
43	+1263	+332	12.92	13.48	29748.245	0.320637	

Refs. 21, 90, 93, 126, 138, 145, 161, 165. Plates in 90, 126.

NGC 6144 α 16^h $24^m.2$, δ $-25°$ $56'$

1	+481	−117	15.3	16.3			

Ref. 187.

NGC 6171 α 16^h $29^m.7$, δ $-12°$ $57'$

1	− 112.8	−522.0	]14.16	[16.75			long per.
2	+ 148.8	−388.8	15.62	16.29			
3	− 224.4	−183.6	15.55	16.14			
4	− 99.6	−156.6	15.64	16.14			
5	+ 231.0	−161.4	15.74	16.21			
6	− 10.8	− 67.2	15.68	16.15			
7	+ 42.0	− 61.2	15.57	16.64			
8	+ 12.0	− 42.0	15.57	16.52			
9	− 26.4	− 19.8	15.91	16.33			
10	− 57.0	+ 8.4	15.48	16.65			
11	+ 9.6	+ 33.0	15.69	16.46			
12	+ 58.8	+ 61.2	15.27	16.48			
13	− 27.0	+ 72.0	15.45	16.59			
14	+ 17.4	+ 82.2	15.35	16.45			
15	+ 19.2	+120.0	15.57	16.12			
16	− 67.2	+113.4	15.69	16.51			
17	− 99.0	+ 71.4	15.35	16.45			
18	+ 77.4	+215.4	15.75	16.46			
19	+ 232.8	+162.6	15.77	16.25			
20	+ 31.2	+ 51.0	15.66	16.40			
21	+ 81.0	−144.6	16.33	16.78			
22	−1354.2	−183.0					
23	− 263.4	+ 19.2	15.61	16.13			
24	0.0	+ 8.4	15.66	16.46			

Ref. 121, with chart.

CATALOGUE—*Continued*

NGC 6205 (Messier 13) α 16h 39m.9, δ +36° 33′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 73.06	− 24.86	13.2	15.0	27685.763	1.45899	816, Sp.
2	− 54.10	− 3.04	12.6	14.1	27308.868	5.11003	306, Sp.
3	−127.70	+ 16.52	15.58	15.79	prob. not var.		135
4	− 47.34	+ 58.18	15.04	15.23	prob. not var.		322
5	+ 71.62	− 14.06	14.33	14.94	24313.429	0.298?	806β
6	+ 92.68	+ 76.60	13.5	14.8	27274.867	2.11283	872, Sp.
7	− 39.78	− 82.72	14.72	15.17	24313.102	0.24?	344
8	− 93.02	+ 11.29	14.2	15.6	28038.654	0.750306	206
9	+ 71.62	− 14.06	14.0	15.1		short?	806α
10	− 5.40	− 70.73	13.1	14.0		semireg.	487, Sp.
11	− 45.78	− 75.88	12.9	13.8		92.5	324, Sp.
12	−105.88	+ 53.46	15.0	15.35	prob. not var.		187
13	− 45.37	− 31.30	14.26	14.50	prob. not var.		327
14	+ 3.18	+207.64	16.16	16.45	prob. not var.		527
15	+ 79.03	−115.34	13.32	13.67		irreg.	835

Var. No. 15 and period for No. 11, found by Arp, unpublished, ref. H. Numbers in right-hand column are identification in Ludendorff's Catalogue, *Potsdam Pub.*, v. 15, no. 50, 1905. Kollnig-Schattschneider's No. 5, for which the Ludendorff no. was erroneously given as 200, is the same as No. 8 above.

Variability of Nos. 3, 4, 12, 13, 14 questioned by Arp and Sawyer from unpublished material. Refs. 18, 20, 23, 27, 29, 30, 37, 40, 76, 133, 134, 142, 147, 165. Plates in 20, 134.

NGC 6218 (Messier 12) α 16h 44m.6, δ −01° 52′

1	+34	−62	11.9	13.2	27306.708	15.508	Sp.

Refs. 11, 102, 113, 123, 124, 165. Plate in 123.

NGC 6229 α 16h 45m.6, δ +47° 37′

1	− 24.6	−105.5	16.84	17.90	
2	− 71.9	+ 4.9	17.18	17.93	
3	−195.7	+ 41.3	17.21	17.82	
4	− 56.8	− 14.3	17.36:	17.89	
5	+ 14.5	+ 44.1	17.21	17.95	
6	+ 44.1	+ 41.5	17.28:	17.96	
7	− 41.7	− 49.9	16.84	18.01	
8	− 4.1	− 42.1	15.30	16.64	l.per. Cep.
9	− 38.9	+ 38.3	17.12:	17.91	
10	− 29.5	+ 72.7	17.28	17.99	
11	+ 23.9	− 25.0	]17.44	18.01	
12	+ 34.2	− 23.6	17.12	18.02	
13	+140.2	+ 61.3	17.15	18.01	
14	− 15.5	− 50.7	16.88	17.95	
15	+ 34.2	+ 27.5	17.39	17.92	

CATALOGUE—*Continued*

NGC 6229

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
16	+ 47.0	− 24.2	17.31	17.94			
17	− 96.3	− 75.0	17.08	17.72			
18	− 36.1	+ 32.2	17.34	18.00			
19	+ 53.4	− 44.4	16.96	18.00			
20	− 27.5	− 36.1	16.91	18.05			
21	+117.3	− 61.6	17.12	17.94			
22	+ 4	− 7	15.2	16.3			prob. slow

Note: Var. No. 1 in 1939 catalogue is now No. 8.
Refs. 36, 113, 156, 187. Plate in 156.

NGC 6235 α 16^h 50^m.4, δ −22° 06′

1	−16	+ 39	16.5	17.2			
2	+58	−211	16.5	17.3			

Ref. 187 with plate.

NGC 6254 (Messier 10) α 16^h 54^m.5, δ −04° 02′

1	+ 5	+ 22	13.2	13.8			Sp.
2	+ 30	+120	11.9	13.7	26607.712	18.754	Sp.
3	−209	+106	13.10	13.82		7.87	

Var. No. 3 found by Arp, unpublished, ref. H.
Refs. 14, 102, 113, 123, 124, 165. Plate in 123.

NGC 6266 (Messier 62) α 16^h 58^m.1, δ −30° 03′

1	+ 41.0	+ 6.1
2	− 26.6	− 68.9
3	− 89.2	− 5.8
4	− 94.6	− 39.6
5	−163.4	+123.4
6	− 81.2	+ 33.1
7	+ 22.6	+169.1
8	− 94.6	+163.4
9	− 92.7	+214.0
10	−452.7	+160.0
11	−456.2	+128.3
12	−203.4	+268.9
13	+ 1.6	+ 30.2
14	− 92.2	+264.7
15	+122.8	+303.0
16	− 74.8	+ 94.1

CATALOGUE—*Continued*

NGC 6266

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
17	− 21.4	+102.7					
18	− 33.4	+ 91.4					
19	− 15.3	+ 65.2					
20	+131.4	+159.8					
21	+105.4	+ 80.6					
22	+ 62.6	+ 12.6					
23	− 74.3	− 37.4					
24	+ 62.6	− 39.0					
25	+150.4	− 73.4					
26	−186.8	−302.1					

Refs. 14, 20 with plate.

NGC 6273 (Messier 19) α 16^h 59^m.5, δ −26° 11′

1	+ 4	+ 48	14.1	15.1
2	+14	+123	13.4	14.7
3	−28	− 6	14.2	15.2
4	− 2	− 24	15.1	15.7

Ref. 152 with plate.

NGC 6284 α 17^h 01^m.5, δ −24° 41′

1	− 24	+ 36	15.6	16.1
2	− 47	− 17	16.1	17.0
3	− 28	− 13	15.3	15.7
4	+ 22	− 18	15.4	16.3
5	+109	−205	16.4	17.0
6	+139	+221	15.9	16.4

Ref. 152 with plate.

NGC 6287 α 17^h 02^m.1, δ −22° 38′

1	−152	−40	16.2	17.1
2	+ 46	−26	15.7	15.9
3	+ 26	+44	16.1	16.8

Ref. 152 with plate.

NGC 6293 α 17^h 07^m.1, δ −26° 30′

1	+ 81.0	+49.5	15.9	16.6
2	−135.6	+64.5	15.8	16.7
3	+ 48.6	+18.6	15.5	15.8
4	+ 92	−81	16.1	17.1
5	+ 78	−83	15.7	16.5

Refs. 51, 152 with plate.

CATALOGUE—*Continued*

NGC 6333 (Messier 9) α 17^h 16^m.2, δ −18° 28′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 91	− 76	15.6	16.9	29427.886	0.585727	
2	+ 40	− 31	15.6	16.4	29436.854	0.628191	
3	+207	−210	15.7	16.85	32000.735	0.605397	
4	+ 23	− 35	15.8	16.95	30520.749	0.670076	
5	+ 34	− 7	16.0	16.8	29435.870	0.274708	
6	− 70	− 14	15.7	16.95	29435.870	0.607795	
7	−111	− 80	15.95	17.2	29434.860	0.628456	
8	− 73	− 99	16.05	16.9			
9	+334	−191	16.0	16.75	30933.704	0.322990	
10	+ 37	+ 26	16.2	16.9	30553.653	0.242322	
11	− 4	− 7	15.7	16.8			
12	−275	−136	15.85	16.95	29408.951	0.571784	
13	+259	+ 11	16.7	17.8	30554.694	0.47985	

Ref. 32a, 87, 163, 177 with plate.

NGC 6341 (Messier 92) α 17^h 15^m.6, δ +43° 12′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	+127.5	+ 41.3	14.64	15.53	27340.211	0.702807	
2	+ 91.2	+ 69.2	14.50	15.52	27340.329	0.643886	
3	+ 53.7	+252.7	14.58	15.70	27340.344	0.637494	
4	− 76.0	+ 58.0	14.52	15.43	27340.111	0.628911	
5	+ 81.6	− 53.7	14.50	15.51	27340.302	0.619707	
6	+ 38.7	+ 43.3	14.53	15.40	27340.360	0.600001	
7	+ 1.6	− 50.5	14.14	14.58	27340.373	0.515075	
8	+208.9	+208.0	14.70	15.79	27430.366	0.6735605	
9	+ 18.0	− 48.1	14.75	15.24	27340.218	0.61	
10	+ 83.0	+ 36.3	14.79	15.39	27340.283	0.377315	
11	+ 71.2	− 67.1	14.74	15.29	27430.301	0.3084416	
12	− 29.9	− 97.8	14.80	15.16	27340.009	0.4099586	
13	+153.4	− 60.1	14.93	15.08			
14	−316.0	+245.7	14.80	15.10	27340.089	0.346178	field, W UMa
15	+ 30	−102	14.6	15.2			
16	− 2	+ 77	14.0	14.5			

Of 2 other stars suspected by Nassau as variables, his No. 15 is considered non-variable, No. 16 is still suspect, ref. 184.

Refs. 64, 76, 114, 120, 125, 153, 184. Plates in 120, 184.

NGC 6356 α 17^h 20^m.7, δ −17° 46′

No.	x″	y″	Max.	Min.
1	− 15	− 24	16.3	17.2
2	+101	−110	16.8	17.1
3	− 24	+ 45	16.0	[17.5
4	+187	+ 47	15.9	[17.5
5	−255	+152	15.7	[17.5

Ref. 187 with plate.

CATALOGUE—*Continued*

NGC 6362 α 17^h 26^m.6, δ −67° 01′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	00	00					
2	− 29	−100					
3	− 83	− 89					
4	− 79	− 88					
5	+ 81	− 14					
6	+ 54	+175					
7	+ 22	+104					
8	−263	+108					
9	−207	+138					
10	+186	+352					
11	− 28	+ 48					
12	−245	−104					
13	−234	−120					
14	+370	+ 28					
15	+ 51	+ 2					

2 unpublished variables.
Refs. 47, 87. No map.

NGC 6366 α 17^h 25^m.1, δ −05° 02′

1	− 26	− 42	15.5	17.0			
2	+305	−390	15.7	16.8			

Ref. 134, with plate.

NGC 6397 α 17^h 36^m.8, δ −53° 39′

1	+210.7	+448.4	11.2	16.0	13727.6	314.6	
2	−279.0	−424.6	13.8	14.8		45 or 60?	
3	−220.0	− 33.5	14.6	15.5	33119.320	0.330667	

Unpublished co-ordinates and magnitudes for No. 3 from Swope, ref. O.
Refs. 11, 20, 66, 90, 183. Plate in 20.

NGC 6402 (Messier 14) α 17^h 35^m.0, δ −03° 13′

1	+ 17	+ 47	14.3	16.0		18.75	Sp.
2	−116	−119	15.4	16.3		2.7952	Sp.
3	− 3	− 90	16.2	17.0			
4	+169	+ 73	16.3	17.5			
5	−136	+ 90	16.1	17.5			
6	+ 34	− 77	15.8	16.4			
7	+ 62	− 97	14.9	16.2		13.59	Sp.
8	+ 96	+ 35	16.6	17.7			
9	+151	− 39	16.3	17.5			
10	− 51	−205	16.3	17.4			

CATALOGUE—*Continued*

NGC 6402

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
11	+196	−223	16.0	17.3			
12	+224	−177	16.2	17.6			
13	− 29	−118	16.3	17.6			
14	+ 54	+ 1	16.2	17.5			
15	−135	+147	16.1	17.5			
16	− 79	− 36	16.2	17.4			
17	−228	+122	14.8	15.7			Sp., field?
18	+ 61	− 22	16.1	17.7			
19	−128	+ 2	16.3	17.6			
20	−145	+ 98	16.3	17.4			
21	+ 72	+125	16.3	17.4			
22	+ 70	+ 95	16.4	17.6			
23	+ 74	+281	15.9	17.4			
24	− 2	+ 75	16.1	17.6			
25	− 28	−312	16.4	17.5			
26	− 85	+ 27	16.5	17.5			
27	−421	+151	15.4	16.2			
28	−465	+372	15.0	16.0			
29	− 68	−152	15.7	16.2			
30	+ 76	− 12	16.2	17.5			
31	− 41	+ 32	16.0	17.0			
32	+ 36	+147	16.2	17.1			
33	−138	+ 12	16.2	17.3			
34	− 70	+ 26	16.4	17.6			
35	−112	− 49	16.2	17.4			
36	+204	−346	16.4	17.5			
37	+ 5	+ 18	16.4	17.7			
38	+ 11	− 17	16.0	17.0			
39	+ 46	− 2	16.1	17.6			
40	+253	+310	16.4	17.1			
41	− 13	− 3	16.0	17.1			
42	+ 36	+ 12	15.9	17.1			
43	+ 68	+ 23	16.2	17.3			
44	+ 20	+116	16.3	17.5			
45	− 90	+ 94	15.7	16.4			
46	+ 91	− 66	16.4	17.4			
47	− 89	+ 26	16.5	17.6			
48	− 4	+ 40	16.3	17.7			
49	− 98	− 19	16.0	16.9			
50	− 15	− 38	16.1	17.0			
51	+104	−305	16.5	17.5			
52	+ 82	+ 39	16.5	17.0			
53	+134	+129	16.4	17.3			
54	+121	+113	16.6	17.6			
55	+ 33	+106	16.5	17.5			

CATALOGUE—*Continued*

NGC 6402

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
56	− 68	−184	16.4	17.4			
57	+134	−116	16.3	17.6			
58	−123	− 34	16.4	17.3			
59	− 32	+ 30	16.4	17.7			
60	+ 41	+ 54	16.2	17.7			
61	+ 12	− 43	16.1	17.7			
62	−232	−154	16.5	17.6			
63	+122	− 63	16.5	17.4			
64	− 51	−169	16.5	17.5			
65	−125	+ 13	16.4	17.2			
66	−133	+ 37	16.6	17.4			
67	+ 34	+ 14	16.1	17.5			
68	+ 10	− 19	16.6	17.5			
69	+140	+ 26	16.6	17.3			
70	+ 43	− 23	16.0	17.2			
71	−116	− 50	16.5	17.7			
72	+122	−119	16.5	17.5			

Refs. 102, 113, 117, 123, 165. Plate in 123.

NGC 6426 α 17^h $42^m.4$, δ +03° 12′

1	−170	+44					
2	−204	−53					
3	− 94	−33					
4	− 77	−74					
5	− 68	−22					
6	− 46	+52					
7	+ 10	− 4					
8	− 15	−53					
9	− 39	−85					
10	+ 46	+11					
11	+285	− 7					prob. field

Variables found by Baade, unpublished, ref. I; positions measured by Sawyer, ref. R.

NGC 6522 α 18^h $00^m.4$, δ −30° 02′

1	−67.5	+34.4	17.29	17.65	32416.672	0.269949	222
2	+ 0.5	+39.7	17.18	18.28	32740.861	0.481903	133
3	+14.7	+37.2	17.30	18.11	32705.874	0.223892	44
4	+25.6	+ 8.3	17.27	18.59	32387.747	0.563826	170

Catalogue—*Continued*

NGC 6522

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
5	+66.0	−42.6	17.62	18.09	32349.871	0.222755	37
6	+96.5	+30.5	17.77	18.23	32416.753	0.192392	247
7	−51.5	+62.7	17.02	17.61		irreg.	172, field
8	−20.2	+49.6	15.94	17.11	32290.987	0.635019	27, field
9	−19.5	−64.9	16.79	17.27	32740.786	0.426448	232, field

New variables found by Baade, light elements by S. Gaposchkin, ref. I.

Baade considers Nos. 2, 3, 4, 5, cluster members, Nos. 1 and 6 possible members, 7, 8, 9, field stars. Numbers at right are those assigned by Baade and Gaposchkin to variables in this galactic centre field.

Ref. 164.

NGC 6528 α 18ʰ 01ᵐ.6, δ −30° 04′

Baade finds a few variables from rich galactic centre field projected against this cluster, but considers no variables yet found are cluster members. Ref. I.

NGC 6535 α 18ʰ 01ᵐ.3, δ −00° 18′

1	−197	+65	16.3	17.3			

1 variable unpublished? Ref. A.

Ref. 187 with plate.

NGC 6539 α 18ʰ 02ᵐ.1, δ −07° 35′

1 unpublished variable. Ref. A.

NGC 6541 α 18ʰ 04ᵐ.4, δ −43° 44′

1	−18	−126	12.5	[16			

New position for Wood's variable determined by McKibben-Nail, ref. J.

Refs. 63, 70. No map.

NGC 6553 α 18ʰ 06ᵐ.3, δ −25° 56′

1	+186	+ 20				0.5642	
2	+ 75	−152				0.5818	prob. field
3	− 23	− 38				0.4886	
4	+ 16	− 2				]100	
5	− 71	− 12				]100	
Nova	−131:	−281:	8	[12	30955		N Sgr 1943

2 suspected variables.

Unpublished data on new variables from Thackeray, co-ordinates of nova by Thackeray and Morrisby, ref. P.

Refs. 51,166 (cluster no. is misprinted as 6533), 178. No map.

CATALOGUE—*Continued*

NGC 6584 α 18^h 14^m.6, δ −52° 14′

No variable in cluster. Ref. 71. No map.

NGC 6626 (Messier 28) α 18^h 21^m.5, δ −25° 54′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+174.0	+188.5	15.1	16.4			
2	− 47.3	+ 63.1	14.3	14.8			
3	− 32.9	+111.0	14.6	15.4			
4	− 34.5	+ 33.6	13.6	14.8	32759.765	14.0 :	Sp.
5	− 44.8	+ 16.4	14.9	15.8			
6	+ 34.1	+ 50.4	14.3	15.2			
7	+172.2	+102.7	15.9	17.0			
8	+227.3	−222.3	14.9	16.3			
9	−158.6	−252.4	14.9	15.9			
10	+ 96	− 79	13.5	14.6			
11	− 14	+ 35	15.0	16.3			
12	+148	− 49	14.9	16.5			
13	− 92	− 24	15.2	16.7			
14	−131	−100	15.7	16.2			
15	−472	−186	15.8	17.0			
16	+432	−372	15.9	17.0			

Refs. 11, 14, 20, 165, 170. Plate in 20.

NGC 6656 (Messier 22) α 18^h 33^m.3, δ −23° 58′

1	− 54.0	− 10.0	13.9	14.9	29425.892	0.615543	348
2	+158.6	+ 69.2	13.1	14.3	29436.917	0.6418	857
3	+214.7	+420.2	14.6	[15.2	29434.918	0.340	
4	− 4.0	− 68.0	13.6	14.6	29438.96	0.716391	465
5	−178.2	− 33.8	12.0	12.8			158, Sp.
6	− 74.4	−100.0	13.6	14.5	29429.938	0.638547	299
7	−342.4	+411.2	13.5	14.5	29424.947	0.6495191	82
8	− 39.5	− 64.8	12.0	12.7	13373.6	61:	382, Sp.
9	−211.2	− 35.0	12.7	13.3	16761.5	87.71	135, Sp.
10	− 39.0	−125.0	13.5	14.6	29438.919	0.646020	389
11	− 14.4	+ 14.0	12.9	13.8	29436.917	1.69050	461, Sp.
12	+ 0.8	− 77.8	14.2	14.5	var.?		531
13	+ 76.4	+158.9	13.5	14.5	29439.920	0.6725217	719
14	+250.8	+486.4	13.8	[15.5	18160.6	200.2	field, Sp.
15	+115.3	− 83.2	14.0	14.5	29439.844	0.3721	804
16	+185.0	− 17.8	14.0	14.5	29429.938	0.3237	877
17	−438.0	+126.0	14.6	[15			
18	− 86	+433	13.7	14.4	29425.892	0.3249	259
19	− 33	+130	13.9	14.5	29424.947	0.384010	381

CATALOGUE—*Continued*

NGC 6656

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
20	−120	−123	13.7	14.5	29429.938	0.430061	221
21	+ 36	+ 88	13.8	14.8	29425.892	0.3265	601
22	−1089	+213	13.7	14.9	29424.947	0.624538	
23	− 5	− 14	14.1	14.9	29432.919	0.3557	505
24	− 26	+ 10	13.8	14.2	29425.892	0.415:	427
25	+326	+375	13.9	14.4	29425.892	0.4023595	952

Numbers at right identify star in Chevalier's catalogue, *Zô-Sè Ann.*, v. 10, C, pp. 1–51, 1918.

Refs. 11, 14, 20, 48, 68a, 81, 155, 165. Plates in 20, 155.

NGC 6712 α 18^h 50^m.3, δ −08° 47′

1	− 63	− 17	15.8	17.0			
2	+ 71	+ 17	14.0	14.9	28728:	105:	AP Sct
3	− 28	− 96	16.2	17.0			
4	+181	− 28	16.4	16.9			
5	+ 67	− 74	15.6	16.8			
6	+ 18	− 39	15.6	16.6			
7	−130	− 17	14.2	[17.0			
8	+ 24	+ 60	14.6	15.8			
9	− 1	+290	16.4	[17.4			
10	− 99	+ 30	15.2	16.0			
11	−122	−339	16.0	16.6			
12	+ 31	+ 38	16.0	17.4			

Co-ordinates of No. 1 shifted slightly to conform with other variables. Some unpublished variables, ref. A.

Refs. 36, 151, 187. Chart in 151, plate in 187.

NGC 6715 (Messier 54) α 18^h 52^m.0, δ −30° 32′

1	+ 83	+ 10	16.7	17.5
2	− 6	+ 90	16.8	17.5
3	− 14	+ 179	17.1	
4	− 38	+ 311	17.1	
5	− 129	+ 43	17.2	
6	+ 210	− 177	17.0	
7	+ 54	− 165	17.2	
8	+ 365	− 330	16.8	17.6
9	− 67	− 637		
10	+ 115	− 530		
11	− 106	−1086		
12	− 220	− 248	16.7	17.3
13	− 238	+ 451		

CATALOGUE—*Continued*

NGC 6715

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
14	+ 240	+ 213	17.2				
15	+ 124	− 63	17.1				
16	+ 87	− 917					
17	+ 697	− 435					
18	+ 511	+ 382					
19	−1260	− 190	16?				
20	+ 106	+ 95	17.2				
21	+ 85	− 231	17.2				
22	+ 11	− 171	17.2				
23	+ 240	+ 210	17.2				
24	+ 453	+ 55					
25	+ 147	+ 337	16.8	17.4			
26	+ 187	− 150					
27	+ 209	− 306	17.1				
28	+ 68	+ 161	17.1				

Ref. 180 with plate.

NGC 6723 α 18^h 56^m.2, δ −36° 42′

1	+ 75.6	−197.4	15.10	15.80	23618.56	0.5384149	
2	+135.2	− 76.9	14.45	16.05	23618.68	0.5048	
3	−244.9	+ 6.0	14.70	15.80	23618.90	0.4949	
4	+ 17.1	+ 77.4	14.55	15.90	23618.79	0.4524	
5	− 4.8	+ 50.8	15.20	16.00		0.49	
6	+ 7.1	+ 46.2	14.90	16.05	23618.80	0.4812	
7	+197.9	− 70.1	15.20	15.75	23618.91	0.4675	
8	+ 15.9	+ 10.8	14.75	15.60		0.53	
9	+ 73.6	+ 17.2	14.70	15.80	23618.71	0.5779	
10	+149.6	+ 84.2	15.10	15.60	23618.60	0.33855	
11	+133.3	+228.8	14.85	15.65	23618.70	0.5342935	
12	+ 45.1	− 45.0	14.95	15.85	23618.53	0.5333	
13	− 46.8	− 70.8	14.80	16.00	23618.48	0.5078	
14	− 37.9	− 43.0	14.95	15.80	23618.91	0.6190	
15	− 93.4	+165.7	14.40	15.80	23618.74	0.4355162	
16	− 46.4	+ 91.6	14.75	15.65	23618.67	0.4114	
17	+ 43.9	−102.0	14.4	15.7		0.5301595	
18	−139.2	− 24:	14.6	15.3		0.5263801	
19	−174.0	−120:	14.6	15.5		0.5347108	

The three variables found by van Gent have been given numbers 17, 18, 19.
Refs. 14, 20, 73, 74, 91, 96. Plate in 20, charts in 96.

NGC 6752 α 19^h 06^m.4, δ −60° 04′
1 variable, 4′ from cluster centre.
Refs. 11, 14, 20. No map.

CATALOGUE—*Continued*

NGC 6760 α 19^h 08^m.6, δ +00° 57′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+57	− 57	15.7	17.0			
2	− 6	−100	16.7	17.2			
3	+31	− 10	15.5	[17.4			
4	+42	+ 39	15.4	[17.5			

2? unpublished variables. Ref. A.
Ref. 187 with plate.

NGC 6779 (Messier 56) α 19^h 14^m.6, δ +30° 05′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 44.69	+ 74.10	15.0	16.2	30899.341	1.510019	363, Sp.
2	+ 18.16	+ 33.09	15.1	15.6			326
3	+ 25.10	+ 91.69	14.4	15.1		semireg.	337, Sp.
4	−112.13	−159.46	15.9	16.4			141
5	+ 6.79	−134.78	14.4	15.2		semireg.	305
6	− 2.02	+ 37.06	12.9	14.8	30172.7	90.02	284, Sp.
7	+293.48	−213.24	15.6	16.3		irreg.	504
8	− 97.63	−335.90	15.9	16.7		semireg.	150
9	+177	+525	15.6	16.1		semireg.	
10	−431.53	+ 88.33	16.4	17.4	30967.473	0.5988948	
11	−415.58	+283.80	15.5	16.3	33152.555	0.07564	17
12	−243.96	− 95.41	15.6	16.4			68

Right-hand column gives identification no. in Küstner's Catalogue, *Bonn Veroff.*, no. 14, 1920.
Refs. 35, 51, 134, 146, 154, 165, 169, 171, 187. Plates in 51, 134, 154.

NGC 6809 (Messier 55) α 19^h 36^m.9, δ −31° 03′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	+304.2	− 55.6			32413.39	0.57997286	HV 658
2	−214.9	− 26.0			32467.18	0.4061601	HV 659
3	+ 78	−304			32413.22	0.6619023	HV 12213
4	+108	+ 59			32413.34	0.3841702	HV 12214
5	− 41	− 74				0.2?	HV 12215
6	+111	− 20			32413.32	0.388904	HV 12216

Refs. 20, 75, 77, 174. Plate in 20.

NGC 6838 (Messier 71) α 19^h 51^m.5, δ +18° 39′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	+140	+ 24	13.5	14.9			Z Sge
2	+ 44	−146	13.8	14.7			4873
3	+ 44	− 70	15.2	17.0			ecl.
4	+266	+ 31	14.7	15.3			

Number for Var. 2 from Russian catalogue of suspected variables, 1951.
Refs. 83a, 182, 187 with plate.

CATALOGUE—*Continued*

NGC 6864 (Messier 75) α 20^h 03^m.2, δ −22° 04′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 15.6	−83.4					
2	− 9.0	+54.0					
3	+ 18.0	+85.5					
4	− 18.0	−84.6					
5	+108.0	−36.0					
6	+ 8.4	−81.0					
7	− 24.6	+78.0					
8	− 13.5	−41.4					
9	+ 45.6	−24.0					
*10	− 43.5	+50.4					
11	+121.2	+84.0					
12	+ 39.6	+75.0					

*Suspected. Four additional suspected variables, numbered 13–16, are omitted.
Ref. 51, with plate.

NGC 6934 α 20^h 31^m.7, δ +07° 14′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	− 45	− 39	15.9	17.3			
2	− 40	− 14	16.0	17.4			
3	0	+ 58	15.9	17.3			
4	+ 39	+ 58	15.6	17.2			
5	+ 59	+221	15.9	17.2			
6	− 27	− 33	16.1	17.5			
7	+ 92	+ 59	16.2	17.3			
8	+100	+ 50	16.3	17.1			
9	+ 63	+ 18	15.9	17.4			
10	−135	+ 72	15.8	17.2			
11	+ 17	+ 28	16.6	17.5			
12	+ 29	− 44	15.6	17.1			
13	− 47	+ 25	16.0	17.2			
14	− 7	− 90	15.8	17.4			
15	+ 10	− 53	15.2	15.8			
16	+ 36	+ 18	16.1	17.4			
17	− 73	−107	16.2	17.4			
18	+ 49	− 8	16.1	17.1			
19	+ 30	+ 1	15.9	17.4			
20	− 26	+ 17	16.0	17.3			
21	− 35	− 3	16.1	17.5			
22	−240	−173	16.0	17.2			
23	− 31	− 16	16.4	17.4			
24	+ 37	− 53	16.3	17.3			
25	+ 50	+ 37	15.9	17.4			
26	+ 31	−196	16.4	17.2			
27	−148	+180	16.2	17.2			
28	−234	+100	15.7	17.3			

CATALOGUE—*Continued*

NGC 6934

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
29	− 85	−183	15.7	17.3			
30	+161	+127	16.2	17.2			
31	+146	−101	16.0	17.3			
32	− 10	+ 51	15.8	17.1			
33	+ 37	+ 12	16.0	17.2			
34	− 21	+ 16	16.1	17.4			
35	+157	−142	16.0	17.5			
36	+ 10	− 35	15.6	17.0			
37	+ 23	+ 10	16.0	17.3			
38	+ 12	− 18	16.2	17.3			
39	+ 8	− 16	16.1	17.3			
40	− 8	+ 26	15.7	16.3			
41	+ 30	− 39	16.2	17.5			
42	+ 55	+ 20	15.9	17.3			
43	+ 21	+ 27	15.9	17.4			
44	− 43	− 30	15.8	17.3			
45	− 32	− 9	15.8	17.2			
46	+ 14	− 24	16.4	17.4			
47	+ 10	− 26	16.3	17.3			
48	+ 33	+ 52	16.0	17.4			
49	+ 13	− 55	16.2	17.3			
50	+ 15	− 37	16.4	17.3			
51	+ 7	− 25	15.4	16.1			

Refs. 102, 107, 113, 123. Plate in 123.
Numerous periods, all RR Lyrae type, are nearly ready for publication by Sawyer, ref. R

NGC 6981 (Messier 72) α 20^h 50^m.7, δ −12° 44′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 43.5	− 54.0	16.45	17.25	33129.400	0.619818	
2	+ 99.0	+194.4	15.95	17.30	33126.405	0.4652687	
3	− 52.5	− 58.5	16.10	17.30	33809.553	0.4976104	
4	−106.5	+ 37.5	16.25	17.35	33147.462	0.5524877	
5	− 38.4	− 21.6	16.40	17.43	22163.738	0.4991	
6	+ 78.0	+ 78.6	16.70	17.10			
7	− 3.6	+ 55.5	16.20	17.29	22163.896	0.52463	
8	− 6.6	+ 89.4	16.20	17.50	33145.372	0.568392	
9	+ 11.4	+ 50.4	16.30	17.34	22162.61	0.5902	
10	− 48.6	− 73.5	16.20	17.30	33857.504	0.5581805	
11	+ 57.0	− 36.6	16.35	17.25	33856.570	0.521466	
12	+ 9.0	− 21.6	16.31	17.17	22163.90	0.4111	
13	+ 13.5	+ 17.4	16.10	17.15	22161.907	0.54182	
14	− 13.5	+ 36.0	16.40	17.06	22163.90	0.5904	
15	− 64.5	− 21.0	16.20	17.35	33125.435	0.5403524	
16	− 4.5	− 19.5	16.30	17.37	22163.83	0.5641	

CATALOGUE—*Continued*

NGC 6981

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
17	+ 3.6	− 43.5	16.45	17.35	33125.483	0.573539	
18	− 26.4	− 37.5	15.70	16.28	22162.88	0.52016	
19	+ 3.0	+112.5	17.15	17.30	not var.		
20	− 54.6	+ 15.0	16.50	17.40	33857.420	0.595046	
21	− 82.5	+ 12.6	16.10	17.50	33145.370	0.5311618	
22	−113.4	+ 1.5	17.10	17.25	not var.		
23	− 99.0	+116.4	16.20	17.25	33834.550	0.5850834	
24	− 15.6	− 24.0	16.20	16.55	22161.92	0.4973:	
25	−133.5	+ 67.5	16.50	17.15	33481.810	0.3533494	
26	− 91.5	− 45.0	16.90	17.20			
27	+209.4	−234.0	15.85	17.25	33856.560	0.6739040	
28	− 65.4	+ 81.0	16.30	17.15	33853.437	0.5672533	
29	+ 36.0	− 52.5	16.40	17.37	22161.83	0.36865	
30	+ 71.4	− 97.5	16.50	16.90			
31	+ 5.4	+ 36.6	16.50	17.22	22162.02	0.55465	
32	−138.0	− 42.0	16.55	17.30	33834.545	0.5282821	
33	+ 2.4	− 60.6	16.95	17.25			
34	− 6.0	+ 7.5	16.06	16.73			
35	+231	+ 27	16.2	17.4			
36	− 12	0	16.0	16.8			
37	+ 7	− 8	15.5	16.5			
38	+ 5	− 9	16.6	17.3			
39	+195	+243	16.8	17.6			
40	+ 18	+ 16	16.4	17.4			
41	− 15	− 20	16.7	17.5			

Refs. 36, 51, 52, 185, 187. Plates in 51, 185, 187.

NGC 7006 α 20ʰ 59ᵐ.1, δ +16° 00′

1	−177.9	+114.8	
2	− 35.3	− 37.3	
3	− 24.4	+ 34.2	
4	− 21.0	− 41.1	not var.
5	− 20.9	+ 38.4	
6	− 13.5	− 44.5	
7	+ 3.2	− 36.9	not var.
8	+ 34.4	+ 13.5	
9	+ 39.4	+ 16.6	var.?
10	+ 42.8	− 11.8	
11	+148	+ 50	
12	+122.0	− 64.0	
13	+102.7	+ 40.2	
14	+ 35.3	+128.3	
15	− 11.5	+114.8	
16	− 39.6	+135.5	

CATALOGUE—*Continued*

NGC 7006

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
17	− 99.3	+ 85.5					
18	− 29.6	− 89.5					
19	− 0.6	− 25.3			26586.	252:	
20	− 21.2	− 24.4					
21	− 21.5	− 18.4					
22	− 12.6	− 15.8					
23	− 27.6	− 7.5					
24	− 25.8	− 2.9					
25	− 19.2	+ 5.2					
26	− 10.6	− 2.9					
27	− 11.8	+ 0.3					
28	− 15.8	+ 4.3					
29	+ 35.0	+ 31.6					
30	+ 5.2	+ 16.6					
31	+ 10.0	+ 11.2					
32	+ 20.9	+ 13.8					
33	+ 31.9	+ 22.4					
34	+ 26.4	+ 9.2					
35	+ 36.2	− 2.0					
36	+ 25.5	− 3.7					
37	+ 18.9	− 3.4					
38	+ 21.5	− 18.4					
39	+ 11.5	− 25.3					
40	+ 9.7	− 14.3					
41	+ 1.4	− 11.2					
42	+ 9.5	− 7.5					
43	− 4.0	− 28.7					

Data supplied by Sandage who has prepared Hubble's work on these variables for publication in *P.A.S.P.*, with print. Co-ordinates of all variables now on Hubble's system, which differs from Shapley and Mayberry's by x = +3″.2, y = +1″.1. Ref. M.
Refs. 51, 57.

NGC 7078 (Messier 15) $\alpha\ 21^h\ 27^m.6$, $\delta\ +11°\ 57'$

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period	Remarks
1	−118.6	+ 24.4	14.36	15.54	15021.990	1.437478	156, Sp.
2	−171.7	+ 6.0	15.14	15.95	15021.078	0.684270	91
3	−248.0	− 46.8	15.34	16.03	15021.097	0.3891545	61
4	−112.6	−163.6	15.31	16.08	15021.277	0.3135750	162
5	−100.3	−212.5	15.33	16.00	15021.291	0.384619	186
6	+ 24.4	+ 76.5	15.20	16.29	15021.603	0.665971	680
7	+ 10.1	+ 73.2	15.56	16.16	15021.134	0.367586	611
8	− 0.6	+126.8	15.22	16.14	15021.330	0.646251	564
9	+ 15.6	+138.7	15.12	15.98	15021.425	0.715284	632
10	+125.6	+ 1.7	15.50	16.04	15021.370	0.386395	976
11	+172.3	− 21.8	15.28	16.07	15021.243	0.3435678	1034

CATALOGUE—*Continued*

NGC 7078

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
12	+163.0	− 50.7	15.22	16.13	15021.090	0.592934	1017
13	+126.6	− 68.8	15.12	16.20	15021.365	0.574961	980
14	+ 84.1	−256.2	15.44	16.00	15021.128	0.381999	905
15	+ 81.7	−304.1	15.22	16.16	15021.064	0.584386	894
16	+101.9	+129.8	15.50	15.97	15021.556	0.69464	942
17	+ 83.7	+110.6	15.40	15.90	15021.216	0.666979	901
18	+ 77.3	+100.4	15.50	16.00	15021.331	0.37816	886
19	+111.3	+160.4	14.85	16.10	15021.552	0.572293	964
20	+ 81.2	− 9.8	15.27	16.17	15021.261	0.700570	891
21	+ 34.4	− 57.5	15.25	16.20	15021.322	0.624690	732
22	−330.8	− 45.8	15.18	16.04	15021.566	0.721728	30
23	+192.0	+256.1	15.07	15.95	15021.198	0.632690	1053
24	−106.7	− 6.1	15.42	16.17	15021.055	0.369697	173
25	+302.9	− 10.7	15.10	16.00	15021.499	0.665329	1093
26	+ 23.5	+331.9	15.33	15.97	15021.272	0.402326	675
27	+222.5	+248.2	var.?				1065
28	+309.9	+534.2	15.19	16.15	15021.632	0.670640	
29	+163.3	+212.2	15.13	16.06	15021.281	0.574062	1020
30	−165.0	− 3.4	15.42	16.00	15021.293	0.405976	102
31	−112.6	+245.6	15.30	16.07	15021.375	0.435693	164
32	− 50.4	+107.8	15.14	15.98	15021.066	0.605400	332
33	− 41.2	− 29.4					380?
34	− 55.4	− 54.5	var.?				322
35	− 34.0	−163.6	15.40	16.11	15021.278	0.383997	412
36	− 27.7	− 81.6	15.18	16.26	15021.371	0.624142	437
37	− 25.2	− 77.4					451
38	+ 7.6	−146.2	15.29	16.16	15021.328	0.375274	600
39	+ 20.5	−124.8	15.34	16.14	15021.259	0.389984	659
40	+131.8	−116.7	15.34	16.00	15021.320	0.377390	986
41	+ 62.9	− 55.4					835
42	+227.5	− 36.8	15.34	16.07	15021.110	0.360167	1066
43	+416.7	+103.2	15.25	15.88	15021.041	0.406744	1122
44	+ 91.3	+ 3.0	15.20	16.11	15021.373	0.595568	920
45	+ 66.9	− 31.0	15.19	16.14	15021.521	0.66210	854
46	+ 56.0	+ 33.2	15.40	16.32	15021.210	0.692730	814?
47	+ 45.7	− 4.3	15.32	16.04	15021.604	0.662900	
48	+ 59.7	+150.6	15.35	16.17	15021.266	0.378881	827
49	+ 40.3	+166.6	14.75	15.35	15021.037	0.417972	765
50	+165.0	+100.0	15.35	16.00	15021.262	0.29850	1022
51	+ 6.2	+ 91.4	15.51	16.03	15021.158	0.397757	590
52	+192.4	− 22.6	15.12	16.24	15021.106	0.577608	1055
53	− 92.6	−111.0	15.28	15.91	15021.301	0.414135	210
54	+ 10.8	+ 88.4	15.58	16.13	15021.240	0.398325	612
55	+ 65.3	− 18.8	15.49	16.30	15021.675	0.719615	850

CATALOGUE—*Continued*

NGC 7078

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
56	+ 57.4	0.0	15.19	16.11	15021.249	0.570307	820
57	+ 75.2	− 56.4	15.26	15.97	15021.243	0.348935	872?
58	− 55.6	+ 8.8	15.64	16.32	15021.388	0.420463	321
59	+ 41.3	+ 41.5	15.50	16.10	15021.117	0.565260	770
60	+ 53.4	− 59.3	15.29	16.00	15021.118	0.691852	805
61	− 67.3	− 40.2	15.43	16.16	15021.526	0.61030	281
62	− 71.6	+ 39.6	15.65	16.26	15021.161	0.38818	264
63	+ 49.8	+ 31.0	15.54	16.44	15021.076	0.67370	790?
64	− 46.2	+ 19.1	15.61	16.24	15021.207	0.351695	350
65	−102.4	− 38.7	15.43	16.18	15021.377	0.756048	177
66	− 68.4	−112.4	15.41	16.10	15021.191	0.379330	275
67	− 86.6	− 10.4					227
68	− 31.8	+ 12.6					420
69	− 37.0	− 25.2					
70	− 34.0	− 19.2					
71	− 34.8	− 12.6					
72	− 2.2	+ 34.8					556
73	− 3.7	+ 20.0					
74	+ 36.3	− 85.8					754
75	+ 2.2	− 30.3					
76	+ 0.7	− 28.9					
77	− 11.8	− 22.9					
78	− 6.7	+ 47.4					533
79	+ 21.5	− 23.7					
80	− 47.4	− 26.6					345
81	− 21.5	− 5.9					
82	− 20.7	+ 1.5					
83	+ 16.3	− 7.4					
84	+ 18.5	− 16.3					
85	+ 20.7	+ 2.2					
86	+ 12.6	+ 4.4	13.4	14.6			prob. Cep.
87	+ 23.7	− 23.7					
88	+ 2.2	+ 26.6					
89	− 23.7	− 6.7					463
90	+ 31.1	+ 4.4					
91	+ 67.3	+ 28.9					847
92	+ 9.6	− 25.2					610
93	+ 27.4	− 33.3					705
94	+ 3.7	+ 28.9					
95	+ 5.2	− 40.0					599

8 variables still unpublished? Ref. 76. Numbers at right are from Küstner's catalogue, *Bonn Veröff.*, no. 15, 1921. (No. 37 might be 452.)

Refs. 14, 17, 20, 34, 39, 41, 45, 76, 95, 100, 128, 165, 172. Plates in 20, 41, 172.

CATALOGUE—*Continued*

NGC 7089 (Messier 2) α 21^h 30^m.9, δ −01° 03′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period	Remarks
1	+ 25.6	+ 79.4	13.2	14.8	26607.800	15.5647	Sp.
2	− 45.8	+ 71.1	14.6	16.1	21454.971	0.527858	
3	+222.9	− 39.6	15.1	16.4	26921.936	0.619705	
4	− 26.8	+ 31.5	15.2	16.6	26628.644	0.564247	
5	− 44.4	+ 2.1	13.2	14.9	26628.644	17.5548	Sp.
6	+ 11.8	− 45.4	13.2	14.9	22162.928	19.3010	Sp.
7	+153.0	−189.2	15.1	16.4	27274.901	0.594857	
8	− 66.9	− 56.8	15.1	16.4	27273.896	0.643677	
9	−173.2	−128.2	15.2	16.4	27274.901	0.609291	
10	+ 90.6	+ 38.8	15.2	16.4	27275.909	0.466910	Sp.
11	+ 85	+ 8	12.5	14.0	31259.8	67.086	
12	− 62	+ 43	15.1	16.5	26628.776	0.665616	
13	− 77	+ 73	15.1	16.4	26924.972	0.706616	
14	+ 83	− 68	15.4	16.4	20749.843	0.693785	
15	+ 80	− 76	15.7	16.4	26944.880	0.430152	
16	− 31	− 27	15.3	16.5	27275.950	0.655917	
17	+ 2	− 63	15.2	16.3	27274.901	0.636434	

Refs. 11, 13, 14, 16, 20, 88, 102, 112, 123, 165, 169. Plates in 20, 112, 169.

NGC 7099 (Messier 30) α 21^h 37^m.5, δ −23° 25′

1	+ 30.0	− 60.6	14.98	16.31	32414.485	0.74365	
2	+ 58.6	−126.2	14.92	16.04	32060.46	0.6535049	
3	− 96.7	− 39.6	14.91	16.06	32039.59	0.69632	
4	−339:	− 51:	16.4	[18	32450.	11–15	SS Cyg

Refs. 11, 14, 20, 167, L. Plates in 20, 167.

NGC 7492 α 23^h 05^m.7, δ −15° 54′

1	+1.2	+96.6

4 suspected variables and 8 unpublished variables.
Refs. 51, 87. Plate in 51.

REFERENCES TO VARIABLE STARS IN GLOBULAR CLUSTERS IN CHRONOLOGICAL ARRANGEMENT

1. 1889 - Pickering, E. C., *A.N.*, v. 123, p. 207.
2. 1890 - Common, A. A., *M.N.*, v. 50, p. 517.
3. 1890 - Fleming, M., *Sid. Mess.*, v. 9, p. 380.
4. 1890 - Fleming, M., *A.N.*, v. 125, p. 157.
5. 1890 - Packer, D. E., *Sid Mess.*, v. 9, p. 281; *E.M.*, v. 51, p. 378.
6. 1890 - Packer, D. E., *Sid Mess.*, v. 10, p. 107.
7. 1890 - Packer, D. E., *E.M.*, v. 52, p. 80.
8. 1891 - Porro, F., *A.N.*, v. 127, p. 197.
9. 1894 - Pickering, E. C., *A.N.*, v. 135, p. 129.
10. 1895 - Belopolsky, A., *A.N.*, v. 140, p. 23.
11. 1895 - Pickering, E. C., *H.C.*, no. 2; *A.N.*, v. 139, p. 137; *Ap.J.*, v. 2, p. 321.
12. 1896 - Pickering, E. C., *A.N.*, v. 140, p. 285.
13. 1897 - Chèvremont, A., *Bull. Soc. Astr. France*, v. 11, p. 485.
14. 1897 - Pickering, E. C., *H.C.*, no. 18; *A.N.*, v. 144, p. 191; *Ap.J.*, v. 6, p. 258.
15. 1898 - Barnard, E. E., *A.N.*, v. 147, p. 243.
16. 1898 - Chèvremont, A., *Bull. Soc. Astr. France*, v. 12, p. 16, 90.
17. 1898 - Pickering, E. C., *H.C.*, no. 24; *A.N.*, v. 146, p. 113; *Ap.J.*, v. 7, p. 208.
18. 1900 - Barnard, E. E., *Ap.J.*, v. 12, p. 182.
19. 1900 - Pickering, E. C., *H.C.*, no. 52; *A.N.*, v. 153, p. 115; *Ap.J.*, v. 12, p. 159.
20. 1902 - Bailey, S. I., *H.A.*, v. 38.
21. 1904 - Leavitt, H. S., *H.C.*, no. 90; *A.N.*, v. 167, p. 161.
22. 1906 - Barnard, E. E., *A.N.*, v. 172, p. 345.
23. 1909 - Barnard, E. E., *Ap.J.*, v. 29, p. 75.
24. 1909 - Barnard, E. E., *A.N.*, v. 184, p. 273.
25. 1913 - Bailey, S. I., *H.A.*, v. 78, p. 1–98; *Viert. der Astr. Ges.*, v. 48, p. 418.
26. 1913 - Barnard, E. E., *A.N.*, v. 196, p. 11.
27. 1914 - Barnard, E. E., *Ap.J.*, v. 40, p. 179.
28. 1914 - Shapley, H., *Mt. W. Cont.*, no. 91 = *Ap.J.*, v. 40, p. 443.
29. 1915 - Shapley, H., *P.A.S.P.*, v. 27, p. 134.
30. 1915 - Shapley, H., *P.A.S.P.*, v. 27, p. 238.
31. 1916 - Bailey, S. I., *H.C.*, no. 193.
32. 1916 - Shapley, H., *P.A.S.P.*, v. 28, p. 81.

32a. 1916 - Shapley, H., *P.A.S.P.*, v. 28, p. 282.

33. 1917 - Bailey, S. I., *H.A.*, v. 78, pt. 2.
34. 1917 - Bailey, S. I., *Pop. Astr.*, v. 25, p. 520.
35. 1917 - Davis, H., *P.A.S.P.*, v. 29, p. 210.
36. 1917 - Davis, H., *P.A.S.P.*, v. 29, p. 260.
37. 1917 - Shapley, H., *Mt. W. Cont.*, no. 116, p. 79.
38. 1917 - Shapley, H. and Davis, H., *P.A.S.P.*, v. 29, p. 140.
39. 1918 - Bailey, S. I., *Pop. Astr.*, v. 26, p. 683.
40. 1918 - Shapley, H., *Mt. W. Cont.*, no. 151 = *Ap.J.*, v. 48, p. 89.
41. 1919 - Bailey, S. I., Leland, E. F., and Woods, I. E., *H.A.*, v. 78, pt. 3.
42. 1919 - Barnard, E. E., *Pop. Astr.*, v. 27, p. 522.
43. 1919 - Sanford, R., *Pop. Astr.*, v. 27, p. 99.
44. 1919 - Shapley, H., *P.A.S.P.*, v. 31, p. 226.
45. 1919 - Shapley, H., *Mt. W. Cont.*, no. 154 = *Ap.J.*, v. 49, p. 24.
46. 1919 - Woods, I. E., *H.C.*, no. 216.
47. 1919 - Woods, I. E., *H.C.*, no. 217.

48. 1920 - Bailey, S. I., *Pop. Astr.*, v. 28, p. 518.
49. 1920 - Shapley, H., *Mt. W. Cont.*, no. 175 = *Ap.J.*, v. 51, pp. 49–61.
50. 1920 - Shapley, H., *Mt. W. Cont.*, no. 176 = *Ap.J.*, v. 51, p. 140.
51. 1920 - Shapley, H., *Mt. W. Cont.*, no. 190 = *Ap.J.*, v. 52, p. 73.
52. 1920 - Shapley, H. and Ritchie, M., *Mt. W. Cont.*, no. 195 = *Ap.J.*, v. 52, p. 232.
53. 1920 - Turner, H. H., *M.N.*, v. 80, p. 640.
54. 1920 - Turner, H. H., *M.N.*, v. 81, p. 74.
55. 1921 - Larink, J., *A.N.*, v. 214, p. 71.
56. 1921 - Shapley, H., *H.B.*, no. 761.
57. 1921 - Shapley, H. and Mayberry, B. W., *P.N.A.S.*, v. 7, p. 152.
58. 1922 - Baade, W., *Ham. Mitt.*, v. 5, no. 16.
59. 1922 - Bailey, S. I., *H.C.*, no. 234.
60. 1922 - Barnard, E. E., *Pop. Astr.*, v. 30, p. 548.
60a. 1922 - Graff, K., *A.N.*, v. 217, p. 310.
61. 1922 - Larink, J., *Berg. Abh.*, v. 2, no. 6.
62. 1922 - Shapley, H., *H.C.*, no. 237.
63. 1922 - Shapley, H., *H.B.*, no. 764; *A.N.*, v. 215, p. 391.
64. 1922 - Woods, I. E., *H.B.*, no. 773.
65. 1923 - Bailey, S. I., *H.B.*, no. 792.
66. 1923 - Bailey, S. I., *H.B.*, no. 796.
67. 1923 - Innes, R. T. A., *U.C.*, no. 59, p. 201.
68. 1923 - Shapley, H., *H.B.*, no. 783.
68a. 1923 - Shapley, H., *H.B.*, no. 781.
69. 1924 - Bailey, S. I., *H.B.*, no. 798.
70. 1924 - Bailey, S. I., *H.B.*, no. 799.
71. 1924 - Bailey, S. I., *H.B.*, no. 801.
72. 1924 - Bailey, S. I., *H.B.*, no. 802.
73. 1924 - Bailey, S. I., *H.B.*, no. 803.
74. 1924 - Bailey, S. I., *H.C.*, no. 266.
75. 1925 - Bailey, S. I., *H.B.*, no. 813.
76. 1925 - Guthnick, P. and Prager, R., *Sitz. Preuss. Akad. Wiss.*, v. 27, p. 508.
77. 1925 - Paraskévopoulos, J. S., *H.B.*, no. 813.
78. 1926 - Baade, W., *Ham. Mitt.*, v. 6, no. 27, p. 61.
79. 1926 - Baade, W., *Ham. Mitt.*, v. 6, no. 27, p. 66.
80. 1926 - Baade, W., *Ham. Mitt.*, v. 6, no. 27, p. 67.
80a. 1927 - Schilt, J., *Ap.J.*, v. 65, p. 124 = *Mt. W. Cont.*, no. 330.
81. 1927 - Shapley, H., *H.B.*, no. 848.
82. 1927 - Shapley, H., *H.B.*, no. 851.
83. 1928 - Baade, W., *Ham. Mitt.*, v. 6, no. 29, p. 92; *A.N.*, v. 232, p. 193.
83a. 1928 - Baade, W., *A.N.*, v. 232, pp. 65–70.
84. 1929 - Slavenas, P., *A.N.*, v. 240, p. 169.
85. 1930 - Baade, W., *A.N.*, v. 239, p. 353.
86. 1930 - Rybka, E., *B.A.N.*, v. 5, pp. 257–70.
87. 1930 - Shapley, H., *Star Clusters*, pp. 45–46.
88. 1930 - Shapley, H., *Star Clusters*, p. 51.
89. 1931 - Baade, W., *A.N.*, v. 244, p. 153.
90. 1931 - Sawyer, H. B., *H.C.*, no. 366; *Pub. A.A.S.*, v. 7, p. 35.
91. 1932 - van Gent, H., *B.A.N.*, v. 6, p. 163.
92. 1932 - Grosse, E., *A.N.*, v. 246, p. 377.
93. 1932 - Hogg, F. S. and Sawyer, H. B., *P.A.S.P.*, v. 44, p. 258.
94. 1932 - Sawyer, H. B., *H.C.*, no. 374.
95. 1932 - Wemple, L., *H.B.*, no. 889.

96. 1933 - van Gent, H., *B.A.N.*, v. 7, p. 21.
97. 1933 - Grosse, E., *A.N.*, v. 249, p. 389.
98. 1933 - Guthnick, P., *Sitz. Preuss. Akad. Wiss.*, v. 24, p. 24.
99. 1933 - Hertzsprung, E., *B.A.N.*, v. 7, p. 83.
100. 1933 - Levy, M., *H.B.*, no. 893.
101. 1933 - Müller, Th., *Berl. Babels., Veröff.*, v. 11, p. 1.
102. 1933 - Sawyer, H. B., *Pub. A.A.S.*, v. 7, p. 185.
103. 1933 - Shapley, H., *Hand. d. Astr.* v. V, p. 719.
104. 1934 - Baade, W., *P.A.S.P.*, v. 46, p. 52.
105. 1934 - Guthnick, P., *Sitz. Preuss. Akad. Wiss.*, v. 25 = *Naturwiss.*, v. 22, p. 319.
106. 1934 - Sawyer, H. B., *Pub.A.A.S.*, v. 8, p. 20.
107. 1934 - Sawyer, H. B., *Pub.A.A.S.*, v. 8, p. 149.
108. 1935 - Baade, W., *Mt. W. Cont.*, no. 529 = *Ap.J.*, v. 82, pp. 396–412.
109. 1935 - Greenstein, J. L., *A.N.*, v. 257, pp. 301–30.
110. 1935 - Greenstein, J. L., *H.B.*, no. 901, p. 11.
111. 1935 - Miczaika, G. R., *Pop. Astr.*, v. 43, p. 260.
112. 1935 - Sawyer, H. B., *Pub. D.A.O.*, v. 6, no. 14.
113. 1936 - Shapley, H., *Hand d. Astr.*, v. VII, p. 536.
114. 1937 - Guthnick, P., *Viert. der Astr. Ges.*, v. 72, p. 160.
115. 1937 - Joy. A. H., *Pub. A.A.S.*, v. 9, p. 45.
116. 1937 - Martin, W. Chr., *Photographische Photometrie van Veranderlijke Sterren in ω Centauri.* (Proefschrift) Leiden, Luctor et Emergo.
117. 1937 - Sawyer, H. B., *J.R.A.S.C.*, v. 31, p. 57.
117a. 1938 - Luyten, W. J., *Pub. Obs. Univ. Minn.*, II, no. 6.
118. 1938 - Martin, W. Chr., *Leiden Ann.*, v. 17, pt. 2, pp. 1–166.
119. 1938 - Martin, W. Chr., *B.A.N.*, v. 8, p. 290.
120. 1938 - Nassau, J. J., *Ap.J.*, v. 87, p. 361.
121. 1938 - Oosterhoff, P. Th., *B.A.N.*, v. 8, p. 273.
122. 1938 - Sawyer, H. B., *D.D.O. Comm.*, no. 1.
123. 1938 - Sawyer, H. B., *Pub. D.A.O.*, v. 7, no. 5.
124. 1938 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 2.
125. 1939 - Hachenberg, O., *Zeit. f. Astr.*, v. 18, p. 49.
126. 1939 - Greenstein, J. L., *Ap.J.*, v. 90, p. 401.
127. 1940 - Dowse, M., *H.B.*, no. 913.
128. 1940 - Dodson, H. W., Cornwall, E. R., Thorndike, S. L. *Pub. A.A.S.*, v. 10, p. 48.
129. 1940 - Hertzsprung, E., *B.A.N.*, v. 9, p. 117.
130. 1940 - Joy, A. H., *Mt. W. Cont.*, no. 637; *Ap.J.*, v. 92, p. 396.
131. 1940 - Martin, W. Chr., *B.A.N.*, v. 9, p. 60.
132. 1940 - Oosterhoff, P. Th., *B.A.N.*, v. 9, p. 57.
133. 1940 - Sawyer, H. B., *Pub. A.A.S.*, v. 10, p. 66.
134. 1940 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 5.
135. 1940 - Schwarzschild, M., *H.C.*, no. 437.
136. 1940 - Wright, F. W., *H.B.*, no. 912.
137. 1941 - Oosterhoff, P. Th., *Leiden Ann.*, v. 17, pt. 4, pp. 1–48.
138. 1941 - de Sitter, A., *Natuur. Tijds. Ned. Indie.*, dl. 101, afl. 2, pp. 51–3.
139. 1941 - Shapley, H., *P.N.A.S.*, v. 27, pp. 440–45; *Harv. Repr.*, no. 228.
140. 1941 - Wright, F. W., *H.B.*, no. 915.
141. 1942 – Hett, J. H., *A.J.*, v. 50, pp. 77–91.
142. 1942 - Kollnig-Schattschneider, E., *Königstuhl-Heidel. Veröff.*, Bd. 15, no. 2; *A.N.*, v. 273, Heft. 3.
143. 1942 - Kooreman, C. J., *B.A.N.*, v. 9, pp. 271–3.
144. 1942 · Martin, W. Chr., *Ap.J.*, v. 95, pp. 314–8.

145. 1942 - Sawyer, H. B., *J.R.A.S.C.*, v. 36, p. 213; *Comm. D.D.O.*, no. 8.
146. 1942 - Sawyer, H. B., *Pub. A.A.S.*, v. 10, p. 233.
147. 1942 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 11.
148. 1942 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 12.
149. 1942 - Wright, F. W., *H.B.*, no. 916.
150. 1943 - Oosterhoff, P. Th., *B.A.N.*, v. 9, pp. 397–9.
151. 1943 - Oosterhoff, P. Th., *B.A.N.*, v. 9, p. 411.
152. 1943 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 14; *Pub. A.A.S.*, v. 10, p. 334 (Abs.).
153. 1944 - Oosterhoff, P. Th., *B.A.N.*, v. 10, pp. 55–58.
154. 1944 - Rosino, L., *Pub. Oss. Bologna*, v. IV, no. 7.
155. 1944 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 15.
156. 1945 - Baade, W., *Mt. W. Cont.*, no. 706; *Ap.J.*, v. 102, pp. 17–25.
157. 1945 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 17.
158. 1946 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 18.
159. 1947 - Greenstein, J. L., Bidelman, W. P., and Popper, D. M., *P.A.S.P.*, v. 59, p. 143.
160. 1947 - van den Hoven van Genderen, E., *B.A.N.*, v. 10, pp. 241–8.
161. 1947 - de Sitter, A.; Oosterhoff, P. Th., *B.A.N.*, v. 10, pp. 287–303.
162. 1948 - van Gent, H. and Oosterhoff, P. Th., *B.A.N.*, v. 10, pp. 377–82.
163. 1948 - Sawyer, H. B., *A.J.*, v. 53, p. 203.
164. 1949 - Gaposchkin, S., *A.J.*, v. 54, p. 185.
165. 1949 - Joy, A. H., *Ap.J.*, v. 110, pp. 105–16; *Mt. W. and Pal. Repr.* no. 5; *A.J.*, v. 53, p. 113 (1948).
166. 1949 - Mayall, M. W., *A.J.*, v. 54, p. 191.
167. 1949 - Rosino, L., *Pub. Oss. Bologna*, v. V., no. 9.
168. 1949 - Rosino, L., *Pub. Oss. Bologna*, v. V., no. 10.
169. 1949 - Sawyer, H. B., *J.R.A.S.C.*, v. 43, pp. 38–44; *Comm. D.D.O.*, no. 18.
170. 1949 - Sawyer, H. B., *A.J.*, v. 54, p. 193.
171. 1950 - Rosino, L., *Pub. Oss. Bologna*, v. V., no. 12.
172. 1950 - Rosino, L., *Ap. J.*, v. 112, p. 221.
173. 1950 - Thackeray, A. D., *M.N.*, v. 110, pp. 45–48; *Comm. Radcliffe Obs.*, no. 15.
174. 1951 - King, I., *H.B.*, no. 920.
175. 1951 - McKibben-Nail, V., *H.B.*, no. 920.
176. 1951 - Rosino, L., *Pub. Oss. Bologna*, v. V., no. 15.
177. 1951 - Sawyer, H. B., *Pub. D.D.O.*, v. 1, no. 24.
178. 1951 - Thackeray, A. D., *M.N.*, v. 111, p. 206.
179. 1952 - Belserene, E. P., *A. J.*, v. 57, pp. 237–47.
180. 1952 - Rosino, L., *Pub. Oss. Bologna*, v.V., no. 18.
181. 1952 - Rosino, L., *Pub. Oss. Bologna*, v.V., no. 20.
182. 1952 - Sawyer, H. B., *A.J.*, v. 57, p. 26.
183. 1952 - Swope, H. H., Greenbaum, I., *A.J.*, v. 57, pp. 83–91.
184. 1953 - Arp, H. C., Baum, W. A., Sandage, A. R., *A.J.*, v. 58, pp. 4–10.
185. 1953 - Rosino, L., *Pub. Oss. Bologna*, v. VI., no. 2.
186. 1953 - Rosino, L., Pietra, S., *Mem. Soc. Astr. Ital.*, v. 24, no. 4.
187. 1953 - Sawyer, H. B., *J.R.A.S.C.*, v. 47, pp. 229–236; *Comm. D.D.O.*, no. 34.

Unpublished References, 1939

A. Baade, W., Letter summarizing Mt. Wilson observations.
B. Greenstein, J. L., Letter.
C. Nassau, J. J., Letter.
D. Oosterhoff, P. Th. L., Letter giving Leiden data.
E. Sawyer, H. B., Unpublished observations.
F. Shapley, H., Letter summarizing Harvard data.
G. Hubble, E. P., Conversation with author.

Correspondence of Recent Years Pertaining to this Catalogue

H. Arp, H.
I. Baade, W.
J. McKibben-Nail, V.
K. Oosterhoff, P. Th.
L. Rosino, L.
M. Sandage, A. R.
N. Shapley, H.
O. Swope, H. H.
P. Thackeray, A. D.
Q. Wright, F. W.
R. Unpublished material in files of writer, H. B. Sawyer.

PUBLICATIONS OF
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VOLUME II NUMBER 3

NEW RADIAL VELOCITIES FOR FAINT STARS WITH LARGE TANGENTIAL MOTIONS

BY

NANCY G. ROMAN

1955
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NEW RADIAL VELOCITIES FOR FAINT STARS WITH LARGE TANGENTIAL MOTIONS

By Nancy G. Roman*

A search in recent literature for high-velocity stars revealed about fifty stars whose radial velocities were unknown but whose proper motions and spectral types indicated large space velocities. Many of these were A- and F-type stars for which the high proper motions, if correct, were particularly unusual. Thus it seemed desirable to complete the observational data for these stars by obtaining radial velocities as well as spectroscopic parallaxes and magnitudes. Dr. John F. Heard, Director of the David Dunlap Observatory, kindly agreed to the co-operation of that institution in this project. The author hoped originally that she could complete the major portion of the observing for the programme during a two and a half month visit to the David Dunlap Observatory early in 1953, but the faintness of the stars and unfavourable weather made this impossible. Instead, members of the observatory staff co-operated in securing the necessary plates during the following year.

The spectra were photographed with the 12½-inch camera on the one-prism spectrograph which gives a dispersion of 66 A./mm. at Hγ. These plates were taken and measured in the same manner as those for the large programme being carried out by the observatory on the radial velocities of stars in the A.G. zone, $+25°$ to $+30°$. The measurement of a large number of standard stars taken in connection with both programmes indicates that the velocities are on the international system.[1] At least three good plates were obtained for each star. In addition, a number of less well exposed plates were also measured. These showed no systematic difference when compared with the stronger plates, but, as the accidental errors proved to be larger in most cases, the velocities from these weaker plates were included in the mean with half weight.

Table I contains the data for thirty-seven of these stars. The designation is either the H.D. number or the B.D. number. *V*, *B-V* and *U-B* are respectively the photoelectric yellow magnitude, the blue-yellow colour, and the ultra-violet-blue colour, on the

*Yerkes Observatory, Williams Bay, Wisconsin; visiting astronomer at the David Dunlap Observatory, 1953.

V, B, U system[2] measured at the McDonald Observatory with the 13-inch reflector. The spectral types have been determined from plates of lower dispersion (near 120 A./mm. at Hγ) taken with either the 40-inch refractor of the Yerkes Observatory or the 82-inch reflector of the McDonald Observatory and are on the MK system.[2] For stars earlier than F2, it is impossible to distinguish between luminosity classes IV and V on the plates used, and for these stars the symbol "V" is used to indicate that the star is not a giant. It is likely that all of these stars are dwarfs. The probable errors are computed from the range of the individual velocities according to the factors given by Schlesinger.[3] An asterisk refers to a note at the end of the table.

For a few stars on the original list the high tangential velocities were found to be spurious because of errors in the published spectral types; several stars proved to be too faint for the programme; and two are in the *General Catalogue of Stellar Radial Velocities*[4] which appeared while the programme was in progress. Table II lists the data for eight of these stars for which at least one good plate was obtained before they were dropped from the list. These velocities are of much lower weight than those in Table I and are given only because, where no other measure is available, these might prove useful for statistical discussions. The arrangement of the data is the same as that in Table I.

Table III lists the proper motions, spectroscopic parallaxes, space velocities, and the elements of the galactic orbits for the stars in Tables I and II. The sources of the proper motions are as follows: Yale, the photographic repetition of the AG zones;[5] GC, the Boss *General Catalogue*;[6] Yerkes, a Yerkes parallax series; AGK_2, the *Zweiter Katalog der Astronomishen Gesellschaft*;[7] Oxf., the *Astrographic Catalogue*, Oxford Section;[8] and GFH, proper motions computed from the positions in the *Geschichte des Fixsternhimmels*,[9] in the *Index der Sternörter*,[10] and the Yale positions. X, Y, and Z are the velocities relative to the local centroid in the directions (l = 57°.5, b = 0°), (l = 147°.5, b = 0°), and b = 90° respectively. In computing the orbits, it is assumed that they are Newtonian orbits passing through the sun's neighbourhood which is 8.2 kpc. from the galactic centre and at which the circular velocity is 216 km./sec. A more careful investigation of the proper motions of the stars on this programme indicates that some of the motions were based on erroneous AG positions and that hence, the high velocities originally derived were fictitious. This is the case for B.D. + 53° 104, H.D. 24000, H.D. 27821, B.D. + 29° 734, H.D. 36542, B.D. + 50° 1359, and H.D. 104817. The high velocity for B.D. + 53° 104 now results from the very small parallax and is probably not significant. As is indicated in the notes to Table I, the observational data for H.D. 11397 appear to be contradictory.

The occurrence of radial velocities larger than 60 km./sec. for one quarter of the stars in Table I (although these were chosen for high tangential motions) substantiates the fact that most of these stars are really high-velocity stars. The subdwarfs have already been discussed and shown to belong to an extreme high-velocity group.[11] Several of the stars show their membership in the high-velocity class by the decided weakness of their spectral lines; as indicated in the notes, two of the latter may be somewhat below the main sequence. Perhaps the most interesting stars are the apparently normal A dwarfs, H.D. 60778, 74721, 86986 and 117880, whose space velocities relative to the sun are 258, 323, 363 and 384, km./sec. respectively. Although effectively all of these motions are in the tangential direction, the proper motions have been checked and the stars would have to lie appreciably below the main sequence to reduce these velocities to values of the order of 40 km./sec.

The author wishes to express her sincere appreciation to the members of the David Dunlap Observatory Staff for their willing co-operation in this project. The programme was supported by a grant from the United States Office of Naval Research.

References

1. *Trans. I.A.U.*, vol. 7, p. 311, 1950.
2. Morgan, W. W. and Johnson, H. L., *Ap. J.*, vol. 117, p. 313, 1953.
3. Schlesinger, F., *A.J.*, vol. 46, p. 161, 1937.
4. Wilson, R. E., Carnegie Inst. Wash. Pub. 601, Washington, 1953.
5. *Trans. Yale Astr. Obs.* vols. 4, 5, 7, 9–12, 16–22, 24, 1925–1953.
6. Carnegie Inst. Wash., Washington, 1937.
7. Hamburg-Bergedorf.
8. Edinburgh, 1907.
9. Karlsruhe.
10. Schorr, R. and Kruse, W., Bergedorf, 1928.
11. Roman, N. G., *A.J.*, vol. 59, p. 307, 1954.

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TABLE I

PHOTOMETRIC AND SPECTROSCOPIC DATA FOR PROGRAMME STARS

Name	α (1900)	δ (1900)	Mag. (V)	B–V	U–B	Sp. Type	No. of Plates	Wt.	Rad. Vel. km./sec.	P.E. km./sec.
	h m									
1368	0 12.7	− 0°11′	8.86	+0.53	−0.00	F9 V	4	3½	+ 43.7	1.7
+53° 104	0 31.2	+54 5	10.55	+0.15	+0.01	A0 V	5	4½	− 12.1	5.4
3567	0 33.5	− 8 51	9.27	+0.45	−0.14	F5 V*	4	4	− 50.3	2.3
11397	1 46.9	−16 48	8.93	+0.68	+0.10	G8 III*	4	4	+ 38.5	2.9
13721	2 8.6	−10 13	8.55	+0.28	0.00	F0 V	3	3	+ 0.8	2.5
21543	3 23.4	− 6 52	8.22	+0.62	+0.03	G2 V*	4	4	+ 59.4	1.1
24000	3 44.3	+29 26	8.76	+0.34	+0.24	A2 V	4	4	+ 11.7	2.4
26298	4 4.5	−16 40	8.14	+0.34	−0.05	F2 V	4	3½	+ 81.9	1.0
27821	4 18.4	+ 6 8	8.69	+0.32	0.00	A7 V	4	3½	+ 12.7	2.8
+24° 659	4 21.8	+24 13	9.37	+0.94	+0.51	K3 V	3	2½	+ 62.9	2.4
+29° 734	4 40.3	+29 7	9.88	+0.29	−0.08	B9 V	4	4	+ 12.1	4.3
+55° 960	5 0.2	+55 18	9.33	+0.63	−0.01	G2 V	4	3½	−121.4	3.4
36283	5 25.6	+15 43	8.64	+0.67	+0.12	G5 V	4	3	+ 48.9	2.5
36542	5 27.3	−10 5	8.66	0.00	−0.12	B9 V	4	3½	− 2.0	7.2
+50°1359	6 44.6	+50 46	10.06	+0.20	+0.12	A5 V*	4	4	− 16.7*	13.1
59374	7 24.6	+19 10	8.50	+0.53	−0.10	F8 V*	4	3½	+ 79.9	0.8
60778	7 31.0	+ 0 4	9.10	+0.10	+0.14	A1 V	3	3	+ 39.4	10.5
+25°1981	8 38.5	+25 10	9.35	+0.30	−0.12	F2 sd	4	3½	+ 47.0	4.4
74721	8 40.4	+13 38	8.72	+0.03	+0.13	A0 V	4	3½	+ 9.0	6.4
86986	9 57.1	+15 4	7.99	+0.12	+0.16	A1 V	4	3½	+ 5.7	3.4
97916	11 10.7	+ 2 37	9.22	+0.42	−0.13	F5 V*	4	4	+ 55.4	3.8
+51°1664	11 20.6	+50 55	10.09	+0.83	+0.40	K2 V	6	5	− 80.2	3.4
100363	11 27.8	−11 29	8.64	+0.30	+0.02	F2 V	4	3½	+130.9	4.7
104817	11 59.1	+ 2 1	7.68	+0.22	+0.08	A7 m*	4	4	+ 12.1	2.5
+22°2442	12 3.9	+22 21	9.49	+0.66	+0.04	G2 V	4	3½	− 9.2	1.0

TABLE I (*Continued*)

+13°2698	13 35.0	+13 6	9.36	+0.58	−0.06	F9 V	5	4	− 20.6	4.8
+14°2771	14 36.7	+14 2	8.40	+0.59	+0.06	G2 V	4	4	− 18.3	0.9
136161	15 14.0	− 1 48	8.88	+0.32	+0.19	A3 V	6	5	− 5.8	6.5
142575	15 50.2	+ 5 23	8.62	+0.38	−0.08	F0 V	5	4½	− 64.8	3.0
+26°3578	19 28.4	+26 11	9.36	+0.37	−0.23	F4 sd	4	4	−128.3	4.0
191069	20 2.9	−16 0	8.11	+0.67	+0.22	G5 V	5	4½	− 2.1	0.9
192031	20 7.7	−15 43	8.66	+0.72	+0.16	G8 V	4	4	+ 19.7	2.2
198273	20 44.1	− 9 1	8.42	+0.60	0.00	G2 V	4	3½	+ 27.9	1.3
205027	21 27.3	+ 0 34	8.29	+0.61	+0.06	G2 V	4	4	+ 16.0	0.9
+ 4°4762	21 49.1	+ 4 30	9.30	+0.64	+0.03	G3 V	4	4	− 44.0	1.8
+17°4708	22 6.7	+17 36	9.47	+0.43	−0.21	F6 sd	4	4	−295.6	4.1
224383	23 52.3	−10 12	7.88	+0.63	+0.14	G2 V	4	4	− 27.8	1.3

NOTES TO TABLE I

H.D. 3567 The lines are weak.

H.D. 11397 The star has very weak cyanogen and unusually strong CH. This is typical of the high-velocity giants. The strength of the Sr II indicates that the star is class III but this is inconsistent with the very large proper motion of the star. (See Table III.) The colour is also too blue for a normal G8 giant.

H.D. 21543 This star may be below the main sequence.

B.D. + 50° 1359 The star shows a G-band in spite of its early type. There is no other evidence that the spectrum is composite although the large range in velocity (−63 to +23) may indicate that it is a spectroscopic binary.

H.D. 59374 This star may be below the main sequence.

H.D. 97916 The lines are weak.

H.D. 104817 A metallic line star. The K-line would indicate the type A3.

TABLE II

STARS DROPPED FROM PROGRAMME

Name	α (1900)	δ (1900)	Mag. (V)	B–V	U–B	Sp. Type	No. of Plates	Wt.	Rad. Vel. km./sec.
	h m								
3556	0 33.4	+ 5°29′	8.77	+0.59	+0.10	G0 V	1	1	+30.0
11592	1 48.7	+10 8	6.78	+0.46	−0.05	F5 V	1	1	−20.6
19618	3 4.4	+15 1	9.05	+0.84	+0.51	K0 IV–V	1	1	−23.2
75530*	8 45.4	− 5 9	9.18	+0.74	+0.22	G8 V	1	1	+40.1
+58°1199	9 29.5	+58 23	9.96	+0.63	+0.03	G3 V	2	1½	−16.2
107452	12 16.0	−10 55	8.25	+0.29	+0.10	F0 p*	2	1½	−15.5
107813	12 18.2	− 6 29	9.41	+0.35	−0.11	F2 V*	2	1½	−24.8
117880	13 28.1	−18 0	9.08	+0.04	+0.06	A0 V	3	2½	−44.6

NOTES TO TABLE II

H.D. 75530 One McDonald plate gives the velocity +30.2 km./sec.
H.D. 107452 A strontium star.
H.D. 107813 The lines are very weak although not quite as weak as in an F-type subdwarf.

TABLE III
SPACE VELOCITIES AND GALACTIC ORBITS

Star	μ_α	μ_δ	Source	π_{sp}	X	Y	Z	e	a
					(kilometres/second)				kpc.
	″	″		″					
1368	+0.339	+0.093	Yale	0.011	− 14	+169	− 33	0.74	15.7
+53°104	−0.025	+0.036	AGK_2-Yale	0.00088	+ 89	− 85	+205	1.14	54.1
3567	+0.012	−0.564	Yale	0.0063	−359	−183	+199	0.79	9.5
11397	+0.135	−0.327	Yale	0.0017	−939	−229	−133	10.9	0.8
13721	+0.031	−0.118	Yale	0.0076	− 67	− 3	− 11	0.51	5.3
21543	+0.353	−0.205	GC	0.024*	− 77	+ 68	− 11	0.61	5.4
24000	−0.041	0.000	GFH	0.0030	+ 53	+ 2	− 38	0.54	18.0
26298	+0.044	+0.182	Yale	0.0105	+ 18	+133	− 9	0.68	18.0
27821	−0.019	+0.007	BAN 274	0.0096	+ 14	+ 28	− 4	0.14	9.5
+24°659	+0.367	+0.100	Yale	0.032	− 9	+ 93	+ 39	0.40	9.0
+29°734	−0.025	−0.042	Oxf-Yale	0.00105	− 67	+ 8	−202	0.51	5.3
+55°960	−0.049	−0.366	GC	0.0115	−136	− 27	−117	0.86	4.4
36283	−0.038	−0.374	GC	0.020	− 69	+ 45	− 54	0.54	5.4
36542	−0.014	+0.008	GFH	0.0018	+ 2	+ 29	+ 45	0.14	8.5
+50°1359	−0.033	+0.014	AGK_2-Yale	0.0026	+ 55	+ 39	− 31	0.61	20.4
59374	+0.038	−0.452	GC	0.012	−185	+ 48	− 24	0.98	4.2
60778	−0.036	−0.116	Yale	0.0022	−182	− 38	−179	0.98	4.1
+25°1981	−0.103	−0.334	GC	0.013	−119	+ 29	− 23	0.80	4.5
74721	−0.043	−0.142	GC	0.0021	−271	− 21	−175	0.93	4.2
86986	+0.139	−0.227	GC	0.0036	−233	−230	+ 39	1.00	9.3
97916	+0.218	−0.011	GC	0.0066	+ 25	−119	+103	0.65	17.8
+51°1664	−0.451	+0.074	Yale	0.018	− 37	+ 96	−107	0.47	7.2
100363	+0.038	−0.149	Yale	0.0083	−120	− 51	+ 50	0.81	4.6
104817	−0.114	−0.029	Yale	0.0087	− 40	+ 62	− 1	0.39	6.4
+22°2442	−0.394	+0.044	Yale	0.0105	− 58	+181	− 25	0.76	10.5

TABLE III (*Continued*)

Star	μ_α	μ_δ	Source	π_{sp}	X	Y	Z	e	a
					(kilometres/second)				kpc.
+13°2698	+0.127	−0.286	Yale	0.0087	− 73	−130	− 30	0.68	6.7
+14°2771	−0.382	−0.087	Yale	0.0175	− 74	+ 80	+ 29	0.61	5.6
136161	+0.091	−0.101	Yale	0.0038	− 8	−105	−116	0.46	9.6
142575	−0.289	+0.034	GC	0.0076	−110	+ 32	+ 93	0.76	4.6
+26°3578	−0.004	−0.174	Yale	0.013	−130	+ 29	− 29	0.84	4.4
191069	+0.168	−0.412	Yale	0.025	− 58	+ 15	− 47	0.45	5.5
192031	−0.350	−0.272	Yale	0.024	− 44	− 51	+ 35	0.39	6.1
198273	−0.341	−0.150	Yale	0.0175	− 18	− 77	+ 46	0.34	7.8
205027	−0.290	−0.322	Yale	0.018	− 42	− 87	+ 8	0.46	6.8
+4°4762	+0.280	−0.008	Yale	0.0125	− 8	+ 65	− 62	0.27	8.2
+17°4708	+0.510	+0.071	Yerkes	0.0125	−260	+241	+ 74	0.98	11.3
224383	+0.461	−0.159	GC	0.022	− 75	+ 88	+ 4	0.62	5.7
3556	+0.135	−0.092	Yale	0.0125	+ 24	− 32	− 19	0.25	10.8
11592	−0.177	−0.288	GC	0.020	− 21	− 70	− 30	0.32	7.4
19618	−0.069	−0.297	Yale	0.014	− 54	− 42	− 56	0.44	5.7
75530	−0.209	−0.519	Yale	0.019	−107	+ 5	− 81	0.74	4.6
+58°1199	+0.219	−0.310	Yale	0.0069*	−191	− 78	+149	0.86	4.3
107452	−0.019	−0.034	GC	0.0058	− 7	+ 24	− 29	0.06	7.4
107813	+0.110	−0.071	Yale	0.0058	− 84	+ 66	− 24	0.65	5.2
117880	−0.061	−0.135	Yale	0.0017	−290	+ 51	−247	0.88	4.4

NOTES TO TABLE III

H.D. 21543 This assumes that the absolute magnitude is 5.1.

B.D. +58°1199 A.D.S. 7447, a triple star. To allow for the other components, $0^{m}.6$ has been added to the magnitude given in Table II.

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THE RADIAL VELOCITIES, SPECTRAL CLASSES AND PHOTOGRAPHIC MAGNITUDES OF 1041 LATE-TYPE STARS

JOHN F. HEARD
DIRECTOR

1956
TORONTO, CANADA

THE RADIAL VELOCITIES, SPECTRAL CLASSES AND PHOTOGRAPHIC MAGNITUDES OF 1041 LATE-TYPE STARS

Introduction

In 1946 the late Frank S. Hogg, then Director of this Observatory, set out to design a long-range programme to measure the radial velocities of a large group of late-type stars, believing that stars of this kind had been neglected in comparison with early-type stars. To make the observational material most useful he decided to choose stars for which proper motion data were already available and to choose them so that the observational material would provide information well suited to galactic studies. With these points in mind, he chose the declination zone $+25°$ to $+30°$ which includes both the solar apex and the north galactic pole, and he selected from the Yale *Catalogue of the Positions and Proper Motions* (Schlesinger and Barney, 1933) the stars listed with photographic magnitudes brighter than 9.01 and of spectral types G0 and later for which radial velocities were not then known. The final programme included 1041 stars. Because of systematic errors in the photographic magnitudes of the Yale *Catalogue* the selected stars are for the most part fainter than 9th magnitude, and because of errors in the Henry Draper classification many are of type F.

The observations for this programme occupied a large part of the observing time of the 74-inch telescope from 1946 until 1954. As the observing and measuring of the spectrograms proceeded, it became apparent that the velocity data would be much more useful if spectral and luminosity classes and improved photographic magnitudes could be added. Accordingly, classification and photometric programmes were undertaken for the same stars. The present report combines the results of these three separate programmes.

The Radial Velocities

Observations. In conformity with earlier practices at this Observatory, four or more measurable spectrograms distributed over a reasonable interval of time were obtained for each star; the total number for this programme was about 4600. Eighty-three per cent. of the spectrograms were obtained with the 12½-inch camera of the one-prism spectrograph yielding a dispersion of 66 A./mm.at $H\gamma$, the remainder (mostly of the brighter stars) with the 25-inch camera, dispersion 33 A./mm. Kodak Spectroscopic 103a–O plates were used almost exclusively. Exposure times ranged from one-half hour to two hours.

Throughout the observations of the programme stars, spectrograms were also obtained of a selection of the fainter standard velocity stars of G- and K-type listed in the *Transactions of the International Astronomical Union*, vol. 7; in all, 156 spectrograms of 18 standards were obtained with the smaller dispersion and 45 spectrograms of 14 standards with the larger dispersion. The purpose was to provide a control in the manner outlined below.

All regular observers took part in the observations. Particular credit is due to G. F. Longworth and F. Hawker of the technical staff for much of the observing and for maintenance of the telescope and spectrograph and to Miss Ruth Northcott and Dr. J. B. Oke for their vigilance over the progress of the observing and the maintenance of plate quality.

Measurements. Measurement and reduction were carried out by methods reported in our earlier Publications (vol. 1, nos. 3, 13, and 16). On good quality plates the number of lines measured was about 20. The spectrograms of the standard velocity stars were measured in the same manner as those of programme stars.

Most of the regular members of the staff and a number of summer assistants shared the task of measuring the plates. Miss Northcott supervised the work of the assistants.

Stars of Variable Velocity. A question which merits discussion in any radial velocity study is the incidence of velocity variation. In the past it has been customary to assign variability in a rather arbitrary manner from a look at the individual velocities with allowance for the precision of measurement. We wished to employ a more objective means of deciding to what degree the measures indicated variability. The following method was developed along lines suggested by Dr. Donald A. MacRae.

Reference has already been made to a group of spectrograms of standard velocity stars taken and measured under the same circumstances as the programme stars. We assume that these measures of standards form a population subject to the same error dispersion as the programme stars, except that they lack whatever dispersion may be present among the measures of some programme stars by reason of true variation of velocity. The problem is to identify what programme stars possess this additional "error" dispersion.

Consider first the standard velocity stars.

Say we have h plates of r stars on which we have measured a grand total of N lines.

Let us compute the deviation of each line-measure from the mean for the plate; call these the "within-plate" deviations. Call the sum of the squares of the deviations of all these N lines S_w.

Let us also compute the deviation of each plate mean from the weighted star mean; call these the "among-plate" deviations. Multiply the square of each "among-plate" deviation by the number of lines measured on the plate and call the sum of these products S_a.

Now if there were no source of error other than the errors of setting on the lines, we would have

$$\frac{S_w}{N-h} = \frac{S_a}{h-r}.$$

But we can expect an error involving systematic shift of all lines on a plate for a variety of reasons. Call this the "plate error" and let the estimate of it be ω.

It can be shown that

$$\omega^2 = \frac{1}{N}\left(S_a - \frac{h-r}{N-h} \cdot S_w\right).$$

We evaluated this for "standard" plates for both 66A./mm. and 33 A./mm. dispersions and found

ω = 5.0 km./sec. for the 66 A./mm.

ω = 2.6 km./sec. for the 33 A./mm.

Now consider a programme star for which we have h' plates with a total of N' lines.

We compute S'_w and S'_a for this star.

Then the quantity, F, given by

$$\frac{1}{F} = \frac{S'_w}{N'-h'} \cdot \frac{h'-1}{S'_a} + \frac{N'\omega^2}{S'_a},$$

can be shown to be Snedecor's ratio of variances for degrees of freedom $h'-1$ and $N'-h'$. Using Snedecor's table of F's, — see, for example, Weatherburn (1949)—we can now say whether or not the scatter shown by the programme star's velocity measures from plate to plate is significant If the F value computed exceeds Snedecor's "1% point", then there is a probability smaller than one per cent. that the amount of scatter has arisen by chance and it is strongly suggested that the radial velocity of the star is variable. If the F value exceeds Snedecor's "5% point", but not the "1% point", then the probability that the amount of scatter has arisen by chance is between one and five per cent. and it is less strongly suggested that the star's velocity is variable. If the F value is less than Snedecor's "5% point", we can hardly consider that the observations suggest variable velocity.

For all of the stars we have made this computation and it is on the basis of this that we have assigned positive variability (strongly suggested) or questionable variability (less strongly suggested). We have also used the measures for the standard velocity stars to establish the weights to apply to the different measures in obtaining the mean velocity for a star. We used weight 4 for good plates of the higher dispersion, 1 for good plates of the lower dispersion and $\frac{1}{2}$ for plates on which fewer than 10 lines could be measured.

A more complete study of the available statistical data may be made at a later time.

Spectral Classification

A decision was made during the course of the investigation to reclassify the spectra of all the 1041 stars using the MK system (Johnson and Morgan, 1953). To this end a series of spectrograms of MK standard stars was obtained, using both dispersions and the same emulsion as for the programme stars. For each dispersion, a careful study of the series revealed the criteria which would be most useful in the various ranges of spectral and luminosity classes, and a routine was developed for "converging" on the correct class of a spectrogram, using both the general appearance of the spectrum and the estimated intensity ratios of the lines and making continual reference to the spectrograms of the standards. Evidence has been adduced that the classification made with our spectrograms does not depart systematically from that made with the smaller dispersions and wider spectra on which the MK system was developed.

The classifications reported here are mostly those made by Miss Barbara Creeper (Mrs. V. Gaizauskas) using the 66 A./mm. spectrograms. For a few dozen stars for which there were no plates of this dispersion, classifications made by Dr. Ian Halliday from 33 A./mm. spectrograms were listed.

Difficulty was encountered with the M-type stars. With our spectrograms we found it difficult to assign a sub-classification to those stars which were recognized as giants of spectral class later than M2; all such are listed merely as M III.

Photometry

A casual comparison between the photographic magnitudes of the Yale *Catalogue* and visual magnitudes listed there and elsewhere sufficed to show that the photographic magnitudes are unsatisfactory, the errors sometimes amounting to a magnitude. Therefore it appeared most desirable to undertake a photometric programme for our stars. This was done by Dr. Donald A. MacRae of this Observatory in collaboration with Dr. Jurgen Stock of the Warner and Swasey and the Hamburg Observatories. They will publish soon a more complete account of this work than the following brief summary.

Through the kindness of Dr. O. Heckmann, Director of the Hamburg Observatory, 80 fields distributed around the sky at declination $+27\frac{1}{2}°$ were photographed with the "original" Schmidt telescope at Hamburg. These fields so overlapped that all our programme stars appeared on two films at least. The films, which cover an area 7.5° in diameter, were Perutz Phototechnical B emulsion exposed behind Schott filters BG3 and GG13, each 1 mm. thick. For the measurement of the films, the Eichner Astrophotometer of the Warner and Swasey Observatory was made available through the kindness of the Director, Dr. J. J. Nassau. Many of the films were also measured on the iris photometer of the Hamburg Observatory. Dr. Stock supervised this part of the work.

To make possible the conversion of the astrophotometer readings to magnitudes, 24 sequences, involving 165 of the programme stars between 7.0 mag. and 10.0 mag., were selected. These stars were observed photoelectrically by Mr. G. Bakos, under Dr. MacRae's supervision, using the photometer attached to the 19-inch telescope of this Observatory. Each star was observed twice at least and the magnitudes, reduced to the $B-V$ system of Johnson and Morgan, will be published separately.

Magnitudes, m_e, on the colour system of the Schmidt films were derived from the photoelectric measures by means of the equation,

$$m_e = B+0.33\ (B-V),$$

and the 24 sequences were used to calibrate the astrophotometer measures. The quantities listed in Table I are the resulting photographic magnitudes. It is believed that residual field errors are negligible. The average mean error of a final magnitude is ± 0.045.

Tabulation of Results

The main body of the results is given in Table I. Following is a description of this table.

Column 1 gives the A.G. designations of the stars.

Column 2 gives the H.D. designations where applicable. A note has been added whenever any ambiguity could arise as to either designation or as to which component of a double star is meant.

Columns 3 and 4 give the 1950 positions which have been rounded off from the positions given in the Yale *Transactions*, vol. 24.

Column 5 gives the photographic magnitudes derived by MacRae and Stock as described in the foregoing section. The magnitudes are from the photographic photometry in all cases except for those values marked with an asterisk which refers to stars which, for one reason or another, were measured only photoelectrically.

Column 6 gives the spectral classes assigned from our spectrograms as described in an earlier section. A colon refers to a classification which is doubtful, either because the plates are poor (when no note is given), or for some specific reason referred to in a note. Stars classified as M III are those which have been recognized as giants later than M2 but to which sub-classes could not be assigned with confidence.

(*Continued on page 137.*)

TABLE I

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
14436	225292	00 02.4	+27 23	7.24	G8 III	var.		6	II
14441	111	03.4	28 00	8.36	K5 III	+ 12.9	0.7	5	
4	167	04.0	28 17	7.50	G9 III	+ 4.4	0.3	4	
12	249	04.8	26 10	8.45	K1 IV	+ 15.5	1.6	5	
29	598	07.9	28 23	9.00	M III	- 7.4	1.5	4	
35	664	00 08.4	+29 16	8.88	F5 V	+ 9.0	1.8	6	
37		08.8	30 10	8.54	K0 V	- 3.1	1.0	4	
63		10.8	26 46	10.42	K2 III	- 15.6	1.9	6	
121	1406	15.7	30 07	8.34	K3 III	- 37.1	1.0	4	
131	1501	16.8	26 11	8.55	G8 III	- 10.9	1.2	5	
145	1605	00 17.9	+30 42	8.35	K1 III	+ 10.1	1.2	4	
146	1633	18.1	26 14	9.17	K5 III	+ 23.5	0.8	4	
188	1996	21.8	26 07	9.40	K1 III	var?		6	II
199	2084	22.7	29 49	9.37	G8 II	+ 6.9	1.7	6	
207	2190	23.4	28 40	9.37	M0 III	- 50.7	0.7	4	
225	2315	00 24.6	+25 18	8.96	K3 III	- 35.7	1.5	4	
230	2343	24.8	30 37	9.39	K1 III	var.		7	II
258	2552	26.7	28 33	9.28	K3 III	+ 33.4	1.3	5	
273	2713	28.2	27 50	9.29	F2 IV	- 4.2	2.9	6	
274	2732	28.2	29 15	9.40	K1 III	- 15.1	1.3	4	
288	2839	00 29.3	+28 15	9.24	K1 III	- 26.4	1.2	5	
289	2854	29.4	27 23	9.47	G0 V	- 0.5	1.3	4	
343	3252	33.2	28 50	9.53	K1 III	- 33.4	0.4	4	
352	3333	33.9	29 34	9.27	K0 III	+ 9.5	1.2	4	
366		35.2	25 33	9.79	G8 III	- 14.7	1.6	6	
375	3590	00 36.3	+26 03	8.67	K3 III	+ 0.9	0.8	4	
382	3650	36.8	26 28	9.55	G0 V	- 17.8	2.3	5	
387	3766	38.0	29 44	9.45	F5 V	- 24.5	1.5	4	
412	4006	40.1	29 50	8.63	K2 II-III	- 20.7	0.8	4	
434	4268	42.6	27 41	9.65	K2 III	var?		6	II
444	4312	00 43.1	+25 54	9.43	K5 II	- 18.5	1.2	5	
450	4372	43.7	30 40	8.41*	K1 III	+ 13.6	0.7	4	
452	4388	43.8	30 41	8.80*	K3 III	- 24.8	0.2	4	
467	4550	45.1	26 01	8.16	K0 III	- 4.0	0.6	5	
468	4549	45.1	26 49	9.41	K2 III	- 30.9	0.9	4	
477	4686	00 46.5	+28 27	8.20	G8 III	- 2.0	1.0	4	
486	4744	47.2	30 11	8.71	K0 III	-162.8	1.2	4	III
493	4798	47.6	28 06	8.47	K1 III	- 9.3	1.0	5	
498	4831	48.0	25 19	8.17	G8 III	- 10.7	0.3	5	
510	4963	49.2	27 30	9.06	K1 III	+ 25:5	1.6	5	
521	5007	00 49.7	+25 31	9.14	K1 III	+ 14.3	1.4	5	
527	5092	50.4	30 05	9.05	K3 III	+ 23.2	0.7	4	
533	5137	50.9	29 13	7.49	K0 III	- 10.6	1.2	4	
537	5164	51.1	28 17	8.48	K1 III	+ 14.0	1.1	4	
555	5411	53.6	28 53	9.87	K1 III	- 2.8	1.0	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
559	5449	00 54.0	+28 32	8.73	K0 III	+ 4.8	1.2	4	
560	5462	54.0	26 04	9.73	M III	- 6.5	1.9	4	
571	5585	55.2	29 15	8.64	K3 III	+ 23.9	1.3	5	
574	5584	55.3	30 03	9.18	G0 IV	+ 7.2	1.2	4	
582	5650	55.8	26 31	9.27	K5 III	- 24.4	1.3	4	
586	5705	56.3	+27 23	8.67	K3 III	- 7.6	0.7	4	
600	5917	58.3	28 44	9.35	G8 III	+ 21.8	1.3	4	
614	6132	01 00.2	29 43	9.15	K2 III	- 26.5	2.2	5	
627	6274	01.3	26 17	9.58	F7 V	- 28.1	0.9	4	
628	6286	01.4	26 19	9.35	G2 V	var.		7	II
647	6525	01 03.9	+29 26	9.42	K1 III	- 2.4	1.9	7	
702	7299	10.8	29 28	7.91	G8 III-IV	- 10.3	0.5	4	
704	7300	10.8	26 11	9.54	K2 III	+ 15.9	1.0	6	
706	7308	11.0	25 59	9.81	K5 III	var.		8	II
710		11.2	26 01	11.14	K2 III	+ 14.6	2.1	6	
714	7352	01 11.4	+25 34	8.66	G0 V	- 18.0	1.8	5	
721	7426	12.1	26 11	8.79	K0 III	+ 2.6	1.3	4	
778	8300	19.9	26 18	9.13	K1 III	- 22.1	0.8	4	
812	8747	24.0	26 59	8.07	K0 III	- 5.6	0.6	4	
814		24.1	27 15	10.48	K3 III	+ 30.4	1.6	7	
817	8791	01 24.3	+25 11	9.36	K3 II	- 15.9	1.7	4	
849	9224	28.5	29 09	7.98	G0 V	+ 13.6	0.7	6	
851	9269	29.0	30 22	9.31	K0 III	+ 42.1	1.4	4	
867	9446	30.5	29 01	9.14	G5 V	+ 21.2	0.5	4	
878	9638	32.2	28 51	9.34	K2 II	- 19.1	1.9	4	
887	9714	01 32.8	+28 01	8.16	K1 III	+ 7.7	0.8	8	
903	9984	35.1	25 39	9.83	G8 III	+ 39.4	1.2	5	
916	10095	36.4	27 30	8.53	K3 III	- 36.0	1.0	5	
929	10296	38.4	28 14	9.45	K1 III	- 4.2	2.5	6	
962	10766	43.0	26 09	9.25	F8 IV	+ 6.2	2.1	6	
966		01 43.7	+29 18	9.25	F5 V	+ 1.4	2.6	7	
968	10829	43.8	30 33	8.80	F7 IV	+ 5.2	2.1	5	
973	10866	44.3	25 55	9.09	K3 III	+ 22.9	0.8	4	
977		44.9	28 14	9.57	K1 III	+ 31.6	0.7	4	
983	10981	45.6	30 32	9.19	G8 III	+ 11.3	1.5	5	
991		01 46.7	+28 27	9.66	K0 III	- 65.2	1.1	4	III
993	11120	47.1	25 30	9.33	G8 V	- 3.5	1.4	6	
999	11130	47.3	29 13	8.79	K1 V	- 36.4	1.2	5	
1023	11453	50.3	28 34	8.57	K5 III	+ 5.0	1.0	4	
1026	11464	50.4	25 48	9.02	K0 III	+ 17.8	1.6	6	
1037	11650	01 52.1	+27 36	8.81	K1 II-III	- 3.8	1.7	5	
1042	11680	52.3	27 01	9.16	K1 III	- 32.8	2.0	4	
1046	11721	52.8	25 52	9.21	G8 III	+ 30.9	1.3	4	
1054	11781	53.4	27 14	8.91	G0 V	- 2.4	0.3	4	
1077		55.6	25 33	9.10	G2 V	- 1.1	0.4	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
1082	12029	01 55.8	+29 08	8.96	K2 III	+ 40.0	0.3	5	
1084	12052	56.0	28 37	9.25	G8 III	+ 28.0	1.2	4	
1094	12232	57.8	29 41	8.96	F2 V	+ 8.2	1.9	4	
1097	12260	58.1	29 18	9.27	K2 III	- 3.6	2.3	5	
1102	12402	59.3	28 10	7.60	K1 III	+ 17.4	0.3	5	
1103	12426	01 59.5	+29 31	9.72	K0 III	+ 10.7	1.8	5	
1113	12535	02 00.7	27 15	8.56	K2 III	+ 36.5	1.0	5	
1122	12638	01.5	25 41	8.26	G8 III	- 17.9	1.0	4	
1128	12728	02.6	28 52	9.12	K1 III	- 8.4	1.9	4	
1139	12897	04.1	26 05	8.36	K1 III	+ 0.2	1.4	5	
1143		02 04.8	+29 24	9.58	K0 III	+ 25.4	2.8	5	
1145	13017	05.1	29 20	9.81	K5 III	+ 4.5	0.8	5	
1158		07.5	29 35	9.30	F8 V	+ 28.1	3.0	5	
1178	13565	10.2	30 20	9.00	K0 II	+ 18.6	1.0	4	
1181	13610	10.5	25 09	9.34	F8 IV	- 48.3	0.5	4	
1186	13691	02 11.2	+26 24	8.81	K1 III	- 7.8	0.8	4	
1192b	13747	11.7	28 28	7.72	K1 IV	var?		5	II
1200	13836	12.6	27 08	9.06	G8 V	+ 3.9	0.5	4	
1209	13943	13.5	29 34	9.51	G8 III	+ 18.4	1.0	4	
1222	14146	15.0	28 47	9.07	M0 III	+ 33.4	0.9	4	
1248	14456	02 17.9	28 18	9.14	G8 III	+ 2.8	1.6	5	
1251	14479	18.1	30 27	9.58	K1 II-III	+ 24.8	1.8	6	
1252	14490	18.2	29 42	9.38	F8 V	+ 28.2	2.8	5	
1264		19.2	27 23	9.22	K0 III	- 64.4	0.6	4	III
1265		19.2	30 04	9.24	F2 II :	- 1.9	2.6	6	
1269	14608	02 19.5	+30 06	9.20	K2 III	+ 0.9	1.4	4	
1271	14624	19.4	26 03	9.40	G5 V	+ 50.2	2.5	6	
1292	14875	21.8	29 01	8.94	K3 III	- 9.1	1.3	4	
1293	14876	21.8	27 26	9.48	K3 III	+ 9.0	0.8	5	
1295	14874	21.9	30 25	9.4	G0 V	+ 6.0	1.2	4	
1297	14918	02 22.2	+25 16	8.90	G5 III	- 9.5	1.7	5	
1301	14949	22.4	27 28	9.44	K2 II	var.		6	II
1304	14969	22.6	29 39	8.96	K3 III	- 27.8	0.3	4	
1324	15256	25.3	29 39	8.32	G5 III	- 13.7	0.9	6	
1330	15326	25.8	29 28	8.34	F8 V	- 16.7	1.8	5	
1371	16099	02 33.1	+29 39	9.64	K3 III	- 58.5	1.9	4	
1376	16139	33.4	27 15	9.28	G8 II	+ 26.3	1.8	5	
1429	17119	42.6	30 07	8.97	F5 V	- 14.1	1.4	5	
1436	17190	43.3	25 27	8.76	K1 IV	+ 14.9	0.8	4	
1447	17283	44.3	26 32	9.23	K1 III	- 37.3	1.1	4	
1454	17382	02 45.2	+26 52	8.57	K1 V	+ 9.4	1.4	7	
1455	17396	45.3	30 08	9.22	G0 V	+ 12.6	2.1	6	
1473	17674	48.1	30 05	8.29*	G0 V	+ 5.2	2.3	6	
1474	17673	48.1	30 18	9.23*	K1 III	- 19.8	1.8	5	
1497	17963	51.0	29 54	9.71	F6 V	+ 25.0	2.0	5	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
1516	18189	02 53.1	+25 53	9.41	G8 III	- 21.1	1.3	4	
1517	18202	53.3	28 58	7.55	G8 III	+ 29.6	0.7	4	
1521	18328	54.6	29 31	9.38	F8 V	- 3.0	2.3	5	
1528	18403	55.3	27 08	9.49	G0 IV	- 62.1	1.4	6	III
1530	18450	55.9	26 34	9.31	K2 V	+ 35.7	2.2	6	
1537	18554	02 56.9	+30 25	9.46	K1 III	+ 6.0	1.0	4	
1541	18602	57.4	30 22	9.75	G8 III	- 13.4	1.8	4	
1559	18929	03 00.5	27 23	8.74	G8 III	- 18.6	0.7	5	
1564	19079	02.1	30 00	9.21	F7 IV	+ 21.2	2.0	5	
1572	19165	02.8	27 30	9.06	F6 V	+ 85.4	1.7	5	III
1584	19485	03 05.7	+25 24	8.97	G5 V	var.		17	II
1599	19823	09.2	29 38	9.75	G0 V	- 31.6	0.9	4	
1652	20671	17.6	28 39	9.41	F8 IV	- 19.7	1.1	4	
1653	20680	17.6	26 45	9.59	K2 III	- 12.0	2.1	5	
1699	21451	25.4	26 06	9.34	K3 III	- 19.0	0.7	4	
1727	21820	03 29.1	+29 22	9.43	K0 III	+ 32.2	0.4	6	
1747	22269	33.0	27 26	9.02	K1 III	+ 15.7	0.5	4	
1758	22403	34.2	25 50	8.17	G2 V	var.		6	II
1791	22849	38.2	29 21	9.58	K1 IV	+ 8.1	2.1	4	
1813	23141	40.8	26 13	8.96	K1 III	- 24.9	1.1	4	
1818	23169	03 40.9	+25 34	9.39	G2 V	+ 17.4	0.3	4	
1824	23257	41.7	27 46	7.60	G5 V	+ 49.0	1.3	5	
1894	24301	49.9	26 32	8.77	G0 IV	+ 26.0	1.2	5	
1902	24365	50.6	28 00	9.00	G8 V	+ 21.3	1.4	4	
1906	24399	50.8	26 45	8.89	G8 II	+ 4.6	1.3	4	
1911	24505	03 51.9	+28 03	9.01	G5 III	- 9.4	0.8	4	
1930	24768	54.2	25 08	8.78	G8 III	+ 6.8	0.9	4	
1958	25296	59.2	27 59	8.50	G8 III	- 20.8	1.7	4	
1967	25461	04 00.7	29 04	9.27	K1 V	- 9.3	1.5	5	
1993	25834	03.7	30 08	9.56*	K1 II	+ 22.8	1.3	5	
1999	26081	04 05.6	+25 45	9.16	G8 II	- 11.1	0.9	4	
2000	26090	05.8	29 04	9.16	G0 IV	+ 36.2	0.4	4	
2001	26126	06.0	28 31	8.93	F8 V	+ 2.6	1.1	4	
2009	26372	08.2	26 22	9.50	F8 V	- 10.9	2.8	6	
2023	26710	11.5	26 08	8.00	G2 V	- 9.3	1.6	5	
2025	26766	04 12.0	+29 47	8.62	K1 IV	+ 9.0	0.7	4	
2065	27741	20.6	28 04	9.19	G0 V	- 8.4	1.0	6	
2124	29246	34.3	25 38	9.26	K2 III	+ 39.1	1.1	5	
2157	30111	42.7	28 34	8.31	G8 III	+ 23.0	1.7	6	
2180	30467	46.0	26 56	8.76	F8 IV	- 21.2	1.9	5	
2204	30945	04 49.9	+26 42	9.44	K3 III	+ 27.2	1.7	5	
2248	31782	56.5	25 52	8.20	K0 IV	- 67.8	1.5	5	III
2249	31781	56.6	26 11	9.14	F8 V	+ 22.2	1.2	4	
2255	31867	57.2	25 04	8.86*	G2 V	- 25.4	1.0	4	
2265	32093	58.7	26 35	9.15	G2 V	- 1.0	1.6	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
2271	32387	05 00.8	+24 54	8.26	G8 V	+ 57.9	1.0	4	
2277a	32477	01.4	30 19	9.61	M0 III	+ 36.2	2.2	6	
2298	32835-6	04.0	26 56	8.76	F5 V, A	+ 27.0	3.8	4	N
2302	32963	04.8	26 16	8.36	G2 V	- 62.0	0.4	4	III
2338	33463	08.5	29 51	8.74	M2 III	+ 14.0	2.7	5	
2344	33585	05 09.3	+26 24	7.84	G5 III	var?		5	II
2603		38.8	29 15	9.06	F8 V	- 4.0	1.2	6	
2606		38.8	26 14	10.63*	M0 III	+ 21.8	2.0	4	
2615	37800	39.3	29 50	9.51	F8 IV	+ 3.0	0.7	5	
2627b	37956	40.2	29 11	7.96	K1 III	+ 28.8	1.0	5	
2657	38142	05 41.6	+24 54	9.08	G8 III	+ 23.1	1.6	4	
2672	38261	42.5	25 06	8.98*	K2 III	- 5.1	1.4	4	
2696b	38524	44.5	25 33	7.94	K1 III	- 17.2	0.6	5	
2714	38750	46.0	25 38	9.14	K2 II	- 6.6	1.9	6	
2763	39416	50.4	25 04	8.54	G2 II	+ 0.2	2.5	6	
2784	39713	05 52.3	+29 10	8.86	G5 III	+ 71.9	1.7	5	
2805	39949	54.0	27 19	8.58	G0 II	+ 13.7	1.6	5	
2834b	40280	55.8	25 46	7.83	K0 III	+ 2.0	1.5	5	
2845	40460	57.0	27 16	7.88	K0 III	+ 98.5	1.4	5	III
2940	41430	06 03.1	29 06	9.03	K3 III	+ 21.1	1.9	4	
2946	41456	06 03.3	+26 32	8.82	G8 III	- 21.0	1.6	4	
2967	41708	04.8	27 26	8.81	G0 V	+ 34.8	1.8	6	
2994	41994	06.3	27 12	9.14	G5 II	+ 8.0	0.8	5	
3028	42397	08.5	25 01	8.68	G0 IV	+ 39.8	0.2	4	
3036	42454	08.9	29 30	8.74	G2 Ib	+ 11.4	0.4	4	
3061	42981	06 11.7	+25 16	9.84	K2 II	- 6.4	1.5	4	
3093	43383	13.8	25 31	8.98	F8 V	+ 12.7	1.6	4	
3107	43581	15.0	26 27	9.26	K0 II	+ 47.9	2.2	4	
3113	43693	15.6	28 05	9.39	K2 III	+ 9.6	1.0	4	
3146	44030	17.5	25 38	9.45	K5 III	-103.8	1.1	4	III
3167	44316	06 19.3	+28 56	9.20	K1 III	- 14.0	1.9	4	
3176	44391	19.6	28 01	9.34	K0 Ib	- 9.4	0.8	4	
3194	44615	20.7	29 00	9.32	F6 V	var?		6	II
3204	44780	21.6	25 05	7.76	K2 III	var.		5	II
3240	45207	24.3	29 40	8.48	F8 II	- 35.0	1.9	5	
3247	45336	06 24.9	+29 16	9.58	K5 III	- 1.0	2.7	5	
3255	45427	25.4	27 40	9.23	K1 III	- 51.3	2.1	5	
3288	45800	27.6	25 55	9.52	G8 II	+ 15.5	0.7	4	
3289	45824	27.7	26 41	9.08	K0 III	- 10.1	1.2	6	
3307	46159	29.9	29 27	9.25	G8 III	+ 34.8	2.4	4	
3309	46160	06 29.9	+27 52	9.46	K5 III	+ 7.9	1.8	4	
3320	46277	30.5	28 01	9.07	K0 II	- 2.5	0.4	4	
3326	46336	30.8	27 05	9.19	K0 III	+ 36.6	1.4	4	
3340	46532	31.9	24 58	9.46	K2 III	+ 3.2	1.5	4	
3367	46944	34.2	28 01	9.38	F7 V	+ 65.2	2.2	5	

TABLE I - continued

A. G.	H. D.	R. A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P. E.	Pl.	Ref.
3424	47730	06 38.1	+29 46	9.53	K1 III	+ 5.7	1.2	4	
3433	47836	38.6	27 08	8.78	G8 III	+ 10.0	2.2	4	
3440	47960	39.1	25 31	9.50	M0 III	+ 10.1	1.7	4	
3441		39.3	29 29	9.76	G8 III	- 48.3	1.9	4	
3442	48008	39.2	25 25	9.32	F6 V	+ 1.6	2.8	4	
3471	48591	06 42.3	+29 25	8.76	F8 V	var.		6	II
3474	48640	42.3	24 44	9.54	K1 Ib	+ 24.5	1.6	5	
3475	48638	42.4	27 44	8.40	K3 III	- 35.5	1.3	4	
3504	49141	45.1	26 46	10.30	K0 III	- 1.1	2.0	5	
3513	49365	46.2	28 36	9.00	G0 IV	- 29.3	2.6	4	
3518	49500	06 46.6	+25 33	8.85	K0 III	+ 61.4	2.1	6	N
3615	51101	53.9	24 43	8.06	K0 III	+ 23.4	1.8	5	
3646	51690	56.3	25 18	9.50	F8 V	+ 6.4	1.4	5	
3647	51689	56.3	25 18	8.53	F8 V	+ 23.6	2.7	4	
3654	51834	56.9	29 51	9.02	K4 III	- 13.7	3.3	4	
3657	51886	06 57.1	+26 57	8.68	G8 III	- 6.6	1.5	5	
3668	52071	57.9	27 14	8.57	K2 IV	+ 94.7	2.4	4	III
3669	52101	58.0	29 48	8.98	K0 III	+ 40.0	1.2	5	
3670	52147	58.0	29 17	8.74	G5 III	+ 10.1	1.4	5	
3682		58.3	26 18	9.05	G5 III	+ 18.1	2.6	5	
3708	52765	07 00.5	+25 10	8.83	G8 III	+ 16.9	1.2	5	
3737	53472	03.1	24 56	8.88	K5 III	+ 9.3	2.7	5	
3775	54370	06.6	26 36	9.15	K2 III	+ 23.8	1.5	4	
3792	54825	08.4	26 29	8.24	K0 II	+ 41.5	0.6	4	
3808	55080	09.4	26 39	8.65	G8 II	+ 14.1	1.6	4	
3828		07 10.8	+28 39	9.34	F8 V	+ 7.5	2.1	4	
3834	55578	11.5	28 32	9.58	G8 V	+ 17.7	3.1	5	
3865b	56176	14.0	26 47	7.70	G7 IV	- 5.1	0.7	4	
3866	56224	14.2	26 27	8.86	K3 III	+109.6	2.3	4	III
3873	56418	14.8	26 25	8.98	K1 III	+ 1.1	2.7	4	
3874	56417	07 14.9	+27 14	8.95	G8 III	- 8.8	1.5	4	
3880	56513	15.4	27 21	8.90	G2 V	- 27.4	1.2	4	
3890	56629	15.9	29 17	8.79	G8 III	+ 16.1	1.9	4	
3897	56761	16.4	26 55	8.25	G8 III	+ 0.8	2.5	4	
3918	57267	18.5	26 15	8.65	G2 V	var.		7	N, II
3928	57470	07 19.6	+29 55	9.28	K1 III	- 26.4	1.4	4	
3974	58683	24.7	27 24	8.62	G8 III	+ 55.7	0.5	4	
3980b	58898	25.6	27 39	8.06	K2 III	var?		4	II
4019	59684	29.1	27 14	8.66	K1 III	+ 59.4	2.3	4	
4044		31.4	28 51	9.29	G0 IV	+ 0.6	0.5	4	
4046	60235	07 31.6	+28 37	9.22	K3 III	+ 34.3	3.1	5	
4051	60298	31.8	25 04	8.18	G0 V	-134.5	2.6	4	III
4119	61645	38.2	26 00	9.54	K2 III	- 28.5	3.0	4	
4143	62285	41.1	25 54	7.43	K5 III	+ 1.6	0.9	4	
4152	62567	42.5	26 07	9.34	K5 III	- 6.0	0.6	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
4161	62857	07 43.9	+26 09	9.28	G5 IV	+ 17.1	1.3	4	
4173	63016	44.9	28 48	8.68	G8 III	- 8.2	2.4	5	
4178	63138	45.4	28 53	8.18	K0 III	+ 20.4	1.6	4	
4194	63410	46.7	26 23	8.06	G8 III	+ 81.4	1.4	4	III
4198	63433	46.8	27 29	7.71	G5 IV	- 15.7	0.7	4	
4202	63495	07 47.2	+28 52	9.17	K1 III	- 6.4	3.1	4	
4209	63712	48.3	29 18	8.17	G8 III	var?		5	II
4214	63816	48.8	24 57	8.97	K1 III	+ 8.2	1.7	4	
4261	64833	53.8	26 14	8.81	K1 III	- 35.3	1.7	4	
4303	65934	59.1	26 47	8.87	G8 III	+ 34.4	0.5	4	
4377	67402	08 05.8	27 38	8.17	K0 III	+ 12.4	1.3	4	
4384b	67542	06.5	29 14	7.72	G5 II	var?		6	II
4386	67544	06.4	24 58	8.59	G8 III	+ 3.7	0.9	4	
4389	67613	06.7	25 42	9.35	K5 III	+ 34.2	1.8	4	
4390	67628	06.9	29 16	9.48	K5 III	+ 0.9	0.8	4	
4392	67709	08 07.2	+27 14	9.51	K1 III	+ 45.3	2.7	4	
4430	68724	11.6	26 53	9.21	K0 III	- 32.1	1.3	4	
4451	69312	14.3	27 12	9.10	K1 III	var?		4	II
4453	69349	14.5	27 33	9.04	K1 III	+ 2.9	1.5	4	
4454	69364	14.6	25 00	8.83	K0 III	- 19.6	1.1	5	
4481	69866	08 17.0	+27 02	9.20	K1 III	- 5.3	2.6	4	
4488	70030	17.7	25 30	9.17	K3 III	+ 38.4	2.3	4	
4494	70178	18.5	28 59	9.22	G5 IV	+ 43.4	3.7	4	
4499	70402	19.8	27 41	9.08	G8 III	- 39.6	1.6	4	
4511	70688	21.2	28 55	9.44	F6 V	+ 41.8	1.6	4	
4525	71008	08 23.0	+28 48	9.00	K1 III	- 1.8	3.5	5	
4526	71028	23.1	28 34	9.32	K0 III	var?		5	II
4529	71093	23.4	28 04	7.40	K5 III	+ 24.8	0.6	4	
4531	71132	23.6	28 14	9.32	G8 IV	+ 19.8	2.6	4	
4554	71730	26.7	24 31	8.35*	K0 III	+ 32.8	1.7	4	
4588	72559	08 31.6	+28 37	9.08	F6 V	- 19.4	0.9	5	
4598	72907	33.3	28 53	9.16	G8 II	- 3.8	2.2	4	
4612	73160	34.8	26 25	9.33	K2 III	+ 39.9	0.4	4	
4632	73509	36.8	28 41	9.31	F8 V	var?		4	II
4670	74260	40.9	27 24	9.50	K3 III	+ 12.7	1.8	4	
4671	74348	08 41.4	+28 38	9.43	G0 IV	+ 2.3	2.1	4	N
4682	74624	43.0	28 34	9.02	F5 III	+ 27.8	2.4	4	
4684	74669	43.2	27 47	8.43	K1 IV	+ 27.6	0.8	4	
4690b	74811	44.1	28 21	7.40	G2 IV	- 1.8	0.9	4	
4693	74925	44.9	28 10	9.30	G0 IV	- 13.6	3.1	4	
4702	75216	08 46.7	+29 38	8.71	K2 III	var?		4	II
4714		49.0	25 55	9.13	G0 IV	+ 14.3	2.6	4	
4715	75646	49.0	25 54	9.06	K2 III	- 7.1	2.5	4	
4717	75663	49.3	29 03	9.44	K3 III	+ 20.2	2.7	4	
4727	75935	50.9	27 06	9.35	G8 V	- 18.7	0.7	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
4730	76010	08 51.4	+27 07	9.06	M0 III	+ 29.6	1.2	4	
4743	76332	53.4	28 52	9.34	G2 V	+ 18.6	0.3	4	
4754	76657	55.4	26 41	9.08	K0 III	+ 23.7	1.8	4	
4758	76752	55.9	25 36	7.94	G2 V	- 10.1	0.8	4	
4760	76766	56.0	26 07	8.25	F8 V	+ 15.3	0.3	4	
4764	76864	56.8	29 13	9.46	K3 III	- 0.3	1.9	5	
4768	76866	56.8	24 49	9.32	F5 V	+ 12.2	2.6	5	
4771	76976	57.3	28 52	9.70	M0 III	+ 20.9	2.7	4	
4796	77313	59.6	26 03	8.44	K1 III	+ 16.7	2.1	4	
4799	77444	09 00.3	27 25	9.70	K4 III	- 30.9	1.0	4	
4809	77586	09 01.4	+29 28	9.64	M III	+ 88.2	2.7	4	III
4813	77694	01.9	24 48	9.33	K2 III	+ 42.3	2.5	4	
4814	77729	02.1	26 22	9.42	K2 IV	+104.5	3.3	4	III
4823	77948	03.3	26 20	9.52	K0 III	- 10.7	2.1	4	
4829	78194	04.7	28 12	9.29	K1 II	+ 57.2	3.2	5	
4834	78277	09 05.1	+27 46	8.87	G2 IV	var?		4	II
4835		05.4	27 44	8.76	G0 V	+ 32.6	2.0	4	
4836		05.5	27 45	8.84	G0 V	+ 28.2	0.3	4	
4856	78887	08.4	25 38	9.29	K0 II	0.0	1.4	4	
4859	78967	09.0	29 05	9.30	K1 III	+ 22.0	1.2	4	
4869	79214	09 10.7	+24 30	9.31	K0 III	- 6.3	2.0	4	
4875	79318	11.2	25 30	9.56*	K0 III	- 8.6	3.0	5	N
4878	79373	11.6	25 13	8.46	K3 III	+ 31.6	2.2	4	
4906	80217	16.3	26 28	8.35	K4 III	+ 9.9	1.6	4	
4914	80327	16.9	24 38	8.45	F8 V	- 32.1	3.1	4	
4930	80819	09 19.8	+25 58	9.20	K0 III	+ 74.1	2.2	4	III
4936	81058	21.2	26 08	8.38	K2 III	- 14.6	3.1	4	
4958	81505	23.8	26 34	9.28	G8 III	+ 20.9	0.5	4	
4968	81855	26.0	26 26	9.84	K3 III	+ 1.1	2.0	4	
4994	82331	29.2	27 03	9.21	K1 III	- 5.9	2.2	4	
5030	83098	09 33.9	+27 59	8.53	K2 III	- 6.0	0.9	4	
5038	83224	34.7	24 37	9.63	F6 V	var.		5	II
5041	83341	35.5	25 36	9.86	G8 III	+ 54.8	1.3	5	
5042	83340	35.6	28 14	8.65	G0 IV	+ 23.4	2.9	4	
5054	83617	37.5	25 15	9.56	G0 IV	+ 13.1	2.9	5	
5055	83632	09 37.7	+26 14	9.91	K0 III	+ 89.8	1.6	4	III
5059	83807	38.7	28 11	9.16	F8 V	var.		4	II
5061	83820	38.8	29 06	9.82	K1 III	+ 20.4	1.8	4	
5065	83935	39.5	25 49	8.71	K1 III	+ 15.9	1.7	4	
5083	84440	43.0	27 17	9.13	K1 III	+ 12.2	1.3	5	
5087	84577	09 44.0	+27 23	9.58	K0 III :	- 10.6	1.1	4	
5090		45.1	27 21		F6 V	- 0.5	1.7	5	
5122	85428	49.4	25 21	9.40	K2 III	+ 71.5	2.4	4	III
5126	85440	49.6	28 01	8.94	G8 III	0.0	1.0	4	
5132	85615	50.8	25 54	8.61	K2 III	- 12.1	0.5	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
5145	85946	09 53.0	+27 05	9.13	K0 III	var?		4	II
5147	85976	53.2	26 14	8.98	G8 III	- 10.0	1.8	4	
5156	86131	54.4	28 48	8.96	K2 III	- 18.8	1.0	5	
5159	86168	54.5	25 02	9.70	K1 III	+ 10.3	1.9	4	
5173	86460	56.4	27 46	8.54	G0 IV	+ 5.7	1.5	4	
5179	86590	09 57.2	+24 48	8.95	K0 V	var.		4	II
5180	86680	57.8	28 25	8.78	G0 V	+ 8.4	2.5	5	
5182	86778	58.4	29 02	8.70	K2 III	- 0.3	1.1	4	
5183	86801	58.7	28 48	9.48	G0 V	- 4.6	0.5	4	
5216	87680	10 04.4	29 29	8.82	G2 V	- 25.5	2.4	5	
5223	87804	10 05.3	+27 03	9.46	G8 III	+ 1.6	2.8	4	
5229	88008	06.5	24 48	9.43	G5 V	var?		5	II
5248	88416	09.5	27 21	9.85	K0 IV	- 0.6	2.2	4	
5251	88476	09.9	28 29	8.14	G8 III	+ 4.7	1.7	4	
5254	88532	10.3	28 32	9.78	K0 IV	var.		5	II
5255	88533	10 10.3	+27 40	9.30	G5 V	- 39.3	2.8	4	
5280	89055	14.1	26 07	8.34	G0 V	- 14.4	0.8	4	
5298	89361	16.4	24 37	9.00	K2 III	+ 19.4	2.0	4	
5300	89415	16.9	29 37	9.81	F5 V	+ 14.4	1.4	4	
5308	89557	17.8	29 12	8.79	G8 III	+ 28.3	0.6	4	
5311	89629	10 18.2	+27 59	9.21	G8 IV	+ 18.1	3.1	5	
5312	89631	18.4	26 57	9.06	F5 V	+ 7.7	1.0	4	
5313	89630	18.4	27 08	9.35	F8 V	- 12.2	1.7	4	
5336	90009	21.0	25 49	8.33	K2 III	- 1.0	1.7	4	
5341	90183	22.3	24 52	8.97	G0 V	- 5.3	3.4	4	
5346	90346	10 23.5	+24 58	8.64	K1 III	- 20.0	2.5	4	
5355	90442	24.2	26 54	9.28	K1 V	var.		5	II
5356	90443	24.2	25 12	9.04	K1 III	var.		5	II
5361	90567	25.1	27 28	9.28	F8 V	+ 32.8	3.1	4	
5369	90682	26.0	27 11	9.64	K3 III	+ 6.3	1.7	4	
5377	90841	10 27.0	+28 49	9.64	K2 III	+ 27.3	1.1	4	
5379	90861	27.1	28 50	8.36	K2 III	+ 39.8	0.4	5	
5382	90932	27.6	27 36	9.70	K1 III	- 40.6	1.6	4	
5390	91148	29.0	24 20	8.81*	G8 V	- 24.4	1.0	4	
5393	91164	29.2	24 59	9.07	K0 III	+ 17.1	3.1	4	
5397	91348	10 30.5	+28 02	9.53	G8 III	+ 10.6	2.2	4	
5398	91366	30.5	25 23	9.02	K1 III	- 0.5	3.0	4	
5407	91545	32.0	28 13	8.32	K2 III	- 21.6	1.3	5	
5417	91685	32.9	29 22	9.28	F7 V	- 30.7	4.1	5	
5419	91842	34.0	28 02	9.76	K1 III	+ 39.0	2.9	5	
5420	91855	10 34.0	+26 26	9.76	K0 III	- 6.6	2.9	4	
5421	91950	34.6	25 20	9.28	G2 V	+ 42.0	1.1	5	
5432	92108	35.7	26 11	9.35	K0 III	+ 32.9	1.0	4	
5451	92456	38.1	25 58	9.24	K1 III	+ 23.0	2.7	4	
5475	92824	40.7	26 02	9.34	F8 V	- 10.2	1.8	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
5489	93215	10 43.4	+26 01	9.98	G5 V	- 10.5	1.0	4	
5490	93242	43.6	25 53	9.42	K0 III	+ 7.0	0.7	4	
5503	93391	44.6	27 10	9.30	K5 III	+ 3.3	2.1	4	
5545	94336	50.8	26 28	9.12	M III	+ 6.9	2.8	4	
5565	94833	54.5	25 32	9.39	F8 V	- 21.1	2.3	4	
5567	94834	10 54.6	+24 25	8.6	K1 IV	+ 4.7	1.8	4	
5571	94966	55.5	24 39	8.64	K1 III	- 6.5	1.4	4	
5582	95188	57.1	25 33	9.44	G8 V	+ 6.8	2.7	5	
5591	95363	58.2	27 24	9.64	F7 V	var.		5	II
5593	95364	58.3	24 20	9.37	G2 V	+ 12.3	2.5	4	
5603	95725	11 00.5	+29 12	8.70	K1 II	- 12.8	1.1	4	
5611	95978	01.9	29 27	9.57	K2 III	- 45.4	2.7	5	
5628	96234	03.4	24 30	9.68	K0 III	+ 11.6	1.9	5	
5635	96393	04.3	26 00	9.58	K0 III	+ 15.1	1.3	4	
5671	97476	10.6	27 27	9.58	K4 III	+ 9.4	1.6	4	
5676	97658	11 11.9	+25 59	8.96	K1 V	+ 3.4	1.6	4	
5684	97777	12.7	26 43	9.71	G8 III	+ 1.1	1.8	4	
5698	98155	15.1	25 19	9.17	K0 III	- 6.1	2.1	4	
5713	98562	18.0	23 53	9.59*	G2 V	+ 12.0	3.2	5	
5765	99594	25.0	26 44	9.73	K2 III	- 0.2	1.0	5	
5780	99947	11 27.4	+25 10	9.16	K0 III	+ 39.1	1.6	5	
5781	99957	27.5	25 35	9.58	K3 III	+ 9.8	1.6	4	
5787	100041	28.3	28 44	9.02	M III	+ 87.0	1.3	4	III
5790	100179	29.2	24 35	9.02	K4 III	+ 26.4	1.3	5	
5815	100947	34.6	28 03	9.11	K1 III	- 14.8	2.6	4	
5818	100993	11 34.8	+25 42	8.77	F8 V	+ 11.2	2.8	5	
5829	101289	36.9	25 35	8.49	G0 V	- 8.1	1.4	5	
5838	101396	37.6	26 26	9.30	K1 V	- 6.7	1.4	4	
5847	101856	40.9	27 51	9.27	K0 III	+ 4.6	1.8	5	
5851	101906	41.2	24 17	8.24	G2 V	+ 5.3	0.7	4	
5863	102142	11 42.8	+27 30	8.23	G5 V	+ 9.5	1.0	4	
5864	102161	42.9	25 23	9.07	G0 V	+ 22.2	3.2	5	
5879	102404	44.7	24 42	9.37	K2 III	- 5.3	1.3	4	
5882	102494	45.3	27 37	8.26	G8 IV	- 21.1	0.7	4	
5887	102646	46.6	28 24	8.55	K0 III	+ 12.4	1.0	5	
5922	103614	11 53.4	+25 46	8.87	F6 V	var?		6	II
5946	104076	56.7	24 54	8.88	G0 V	+ 1.9	2.2	5	
5956	104392	58.7	24 30	9.74	K2 III	- 13.1	2.3	5	
5962	104590	12 00.1	24 44	8.95	K2 III	- 3.2	2.8	5	
5964	104589	00.2	25 36	9.36	K1 III	+ 28.0	1.5	4	
5974	104784	12 01.5	+25 13	8.62	F8 V	+ 3.1	2.6	7	
5981	105020	03.0	28 47	9.66	K3 III	- 33.1	3.2	7	
6015	105771	07.9	29 21	8.59	K0 III	- 3.5	1.1	4	
6020	105898	08.7	25 02	8.19	G2 V	- 37.7	2.1	5	
6022	105964	09.1	26 01	9.22	G0 V	+ 14.2	2.5	5	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
6031	106184	12 10.5	+28 55	9.75	K5 III	+ 6.5	1.2	4	
6035	106398	11.8	26 47	8.41	G8 III	+ 58.6	2.4	5	
6052	106857	14.8	29 00	9.54	F5 V	- 6.1	1.4	4	
6054	106947	15.3	25 20	9.31	F7 V	+ 5.0	1.0	4	
6060	107132	16.5	25 07	9.41	F7 V	+ 2.1	2.1	4	
6078	107468	12 18.6	+26 00	9.52	K1 III	+ 34.3	2.0	4	
6085	107611	19.4	27 35	9.04	F6 V	+ 3.2	1.5	4	
6091	107725	20.1	26 54	9.77	K2 III	- 1.7	2.4	4	
6125	108466	25.1	28 23	8.56	K2 III	- 27.1	2.3	4	
6134	108675	26.5	29 10	9.17	F6 IV-V	var?		5	II
6140	108805	12 27.5	+26 24	9.24	G8 III	- 23.0	1.9	4	
6146	108976	28.6	28 00	9.07	F6 V	- 1.2	1.0	4	
6149	109012	29.1	27 20	9.03	K2 III	- 18.1	1.8	4	
6163	109282	31.0	24 43	9.16	M III	+ 0.5	3.2	6	
6170	109463	32.3	24 30	9.35	K5 III	- 26.1	1.7	4	
6172	109482	12 32.3	+29 22	9.31	G8 II	+ 0.7	3.0	5	
6175	109552	33.0	29 07	9.07	F8 IV	+ 20.9	3.1	5	
6177	109627	33.5	25 42	9.10	K2 III	+ 1.0	2.9	5	
6182	109823	35.2	28 54	9.71	G0 IV	+ 8.2	1.6	4	
6222	110788	41.9	28 15	9.35	G8 III	- 30.6	2.9	4	
6227	110883	12 42.6	+27 40	8.98	K2 III	+ 7.0	1.9	4	
6246	111285	45.5	24 22	8.93	G8 III	- 31.2	1.1	4	
6249		45.8	25 25	11.07	K2 III	- 18.2	3.1	5	
6259	111541	47.4	26 42	8.32	K1 III	- 8.6	1.7	4	
6274	111842	49.5	25 57	9.68	K5 III	- 32.5	2.4	4	
6280	112001	12 50.6	+27 04	8.53	G0 IV	- 12.0	2.7	5	
6294	112257	52.7	28 02	8.72	G2 V	- 38.5	1.0	4	
6295	112299	53.0	26 01	9.19	F8 V	+ 3.6	0.4	4	
6313	112753	56.3	27 45	8.81	G0 V	var?		5	II
6321	113094	58.6	24 35	9.31*	K1 III	- 10.3	2.7	5	
6325	113242	12 59.7	+29 16	9.68	F8 V	- 5.7	1.5	4	
6343	113771	13 03.3	26 51	8.77	K0 III	- 8.6	2.2	4	
6359	114037	05.0	26 47	9.06	K1 III	- 6.4	0.7	5	
6364	114093	05.6	25 06	7.99	G8 III	- 5.9	0.9	4	
6368	114172	06.2	29 39	9.29	G0 V	- 36.8	2.2	4	
6385	114636	13 09.1	+26 39	9.77	K1 III	- 24.9	2.2	6	
6407	115103	12.2	29 40	9.23	F6 V	- 9.1	2.9	6	
6411	115256	13.2	29 00	9.06	K3 III	+ 19.2	1.9	5	
6416	115339	14.0	28 00	9.13	G8 V	+ 24.6	2.6	5	
6421	115613	15.6	27 43	9.24	F8 V	+ 3.8	3.2	5	
6430	115762	13 16.5	+24 52	9.39	G2 V	- 12.0	1.8	4	
6435	115929	17.5	28 22	8.76	F6 V	- 12.6	0.7	4	
6438	116029	18.3	24 55	9.05	K1 III	- 2.1	1.9	4	
6443	116232	19.6	26 16	8.76	G8 III	- 22.8	1.8	5	
6454	116329	20.3	26 06	9.52	F7 V	- 27.3	2.2	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
6477	117028	13 24.8	+29 08	9.46	G8 III	+ 26.7	1.2	4	
6478	117062	25.1	24 34	9.02	F2 V	var?		5	II
6501	117555	28.4	24 49	9.02	G5 II	var.		7	N, II
6529		32.8	25 04	9.47	G8 V	- 2.3	0.5	4	
6546	118658	35.6	27 04	9.79	K0 III	- 5.4	2.1	4	
6552	118823	13 36.5	+24 30	9.25	K2 III	- 11.6	2.1	5	
6556	118905	37.1	26 56	8.46	K1 III	+ 0.5	2.5	6	
6559	118971	37.7	26 11	8.91	G8 III	+ 33.1	1.4	5	
6582	119665	41.8	25 32	9.39	F6 V	- 0.8	2.2	4	
6584	119748	42.2	29 14	9.76	K1 III	- 29.9	1.0	4	
6590	119944	13 43.6	+27 29	9.65	K2 III	+ 13.8	2.2	4	
6605	120421	46.5	28 08	8.52	K1 III	- 4.2	1.1	4	
6618	120802	48.9	27 23	9.71	K1 III	var.		6	II
6619	120803	48.9	24 57	9.05	K1 III	- 47.4	2.5	6	
6623	120895	49.5	24 56	9.91	K3 III	- 18.3	0.8	4	
6633	121131	13 50.8	+28 04	9.44	K1 V	+ 40.3	1.4	4	
6634	121149	50.8	27 54	9.29	G0 V	- 22.0	2.0	4	
6638	121184	51.1	24 24	9.89	K3 III	- 18.6	1.7	5	
6639	121183	51.0	27 20	9.57	K0 IV	- 20.7	2.1	5	
6646	121319	51.9	28 34	9.15	K0 III	- 40.0	1.6	4	
6663	121844	13 55.2	+25 15	9.37	K1 III	- 62.1	2.7	4	
6669	122052	56.6	24 56	8.67	G0 III	- 26.1	2.4	6	
6693	122693	14 00.5	24 48	8.74	F8 V	+ 1.0	0.4	4	
6694	122767	01.0	24 50	9.73	K3 III	var.		5	II
6699	122796	01.2	27 45	8.49	K1 III	- 32.5	1.8	5	
6705		14 02.5	+26 05	9.79	K0 V	- 12.7	1.6	5	
6726	123612	06.0	24 33	8.43	K5 III	- 25.4	2.1	4	
6732	123822	07.1	25 41	9.77	G8 III	- 0.3	2.2	4	
6734	123877	07.4	26 05	9.93	K5 III	+ 21.0	2.9	5	
6738	124019	08.2	27 52	9.33	G2 V	- 20.2	0.4	4	
6788	125320	14 15.9	+27 02	9.12	G5 IV	+ 21.1	3.0	4	
6802	125728	18.5	26 18	7.99	G8 II	+ 26.1	1.9	4	
6808	126009	20.0	29 36	8.65	M III	- 14.4	1.7	8	
6820	126307	21.8	27 38	8.45	K4 III	+ 31.6	1.1	4	
6821	126327	21.9	25 56	var.	M III	- 7.7	3.0	5	N
6832	126598	14 23.7	+26 29	9.22	K4 III	var.		7	II
6838	126778	24.7	28 49	9.39	G8 IV	-130.1	1.5	4	III
6847	126970	25.8	29 29	8.91	G5 IV	- 48.1	1.5	4	
6848	126991	26.0	24 44	8.81	G2 V	- 82.9	1.8	4	III
6852	127093	26.5	26 05	8.75	M III	+ 3.9	1.8	4	
6861	127386	14 28.2	+25 19	8.99	pec.	var.		5	N, II
6888		32.2	24 37	9.33	G8 III	- 12.9	2.5	4	
6889	128095	32.1	28 42	9.49	K1 IV	+ 26.3	1.2	4	
6894	128185	32.6	28 37	8.67	F8 V	- 6.5	2.5	4	
6937	129357	39.2	29 17	8.72	G2 V	- 33.9	2.2	4	

A. G.	H. D.	R. A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P. E.	Pl.	Ref.
6940	129412	14 39.5	+24 45	8.27	F7 V	+ 2.5	2.0	4	
6960	130215	43.9	27 43	9.07	K2 V	- 16.2	0.8	4	
6971	130500	45.6	25 41	9.72*	G8 II-III	+ 3.9	3.1	5	
6983	130766	47.0	25 21	8.43	K3 II	- 11.5	1.1	8	
7008	131509	51.1	28 43	9.22	K0 V	- 43.7	2.1	4	
7022	131972	14 53.8	+24 35	8.10	K2 III	+ 4.0	1.8	4	
7032	132256	55.2	25 31	8.16	G2 IV	- 3.9	2.2	4	
7035	132304	55.5	24 52	8.82	K3 III	- 38.3	3.2	4	
7039	132524	56.6	25 15	8.73	K0 III	- 18.4	1.9	4	
7042	132737	57.7	27 21	9.03	K0 III	- 20.7	0.6	4	
7061	133460	01.6	26 14	7.95	F8 V	+ 3.7	0.7	4	
7062	133459	15 01.7	+27 17	8.93	K4 III	+ 8.2	2.1	4	
7079	133922	04.2	26 38	9.78	K4 III	var?		6	II
7089	134246	05.9	28 43	8.47	G8 III	+ 10.4	1.4	4	
7090	134282	06.1	26 54	9.25	G8 II	- 5.2	1.2	4	
7106	134680	15 08.2	+27 37	9.68	G8 III	var.		6	II
7116	135145	10.7	28 07	9.19	G0 V	- 54.4	1.1	5	
7152	136231	16.6	25 57	9.31	G0 V	+ 14.8	1.6	5	
7155	136274	16.9	25 52	8.94	G8 V	- 28.6	1.1	10	
7181	136901	20.3	25 48	8.91	K1 III	var.		9	II
7183	137003	15 20.7	+28 14	8.67	G8 III	- 9.8	1.8	5	
7201	137688	24.4	28 18	9.27	K3 III	+ 28.6	2.1	4	
7220	138156	27.3	27 16	9.55	G5 III	- 36.1	2.2	4	
7256	139007	32.7	25 10	8.75	F8 V	- 22.2	2.6	4	
7276	139550	35.8	25 48	9.41	G8 III	+ 11.1	0.8	4	
7280	139608	15 36.1	+24 41	8.2	M III	- 23.2	1.0	4	
7281	139749	36.9	25 54	8.87	G0 V	+ 8.1	1.6	4	
7298	140385	40.2	29 47	9.37	G2 V	- 44.8	1.4	4	
7326	140913	43.1	28 37	8.81	G0 V	- 14.5	0.2	4	
7333	141176	44.7	25 14	9.07	G2 IV	- 17.5	2.0	5	
7353	141690	15 47.4	+25 37	9.27	G0 IV	var.		5	II
7367	142053	49.4	25 27	8.87	K1 II-III	- 10.6	1.0	5	
7377	142209	50.3	28 45	9.40	K3 III	- 15.8	2.0	4	
7378	142243	50.5	29 04	9.25	K3 III	- 17.5	2.3	5	
7385	142418	51.5	29 37	9.41	K1 III	+ 9.1	2.6	5	
7398	142898	15 54.0	+27 12	9.24	K1 IV	- 31.5	1.2	4	
7399	142929	54.3	25 19	9.01	F8 V	- 34.1	2.0	5	
7415	143271	56.4	27 00	9.43	G8 III	+ 1.3	1.8	4	
7418	143272	56.5	26 41	9.35	K0 II-III	+ 3.6	1.6	4	
7419	143313	56.6	25 43	9.59	K2 V	var.		6	II
7420		15 56.5	+27 53	8.95	K0 V	- 67.4	1.2	4	
7441	143688	58.9	24 36	9.31	F6 V	+ 27.2	3.4	5	
7444	143705	58.9	29 05	8.73	G0 V	var.		5	II
7468	144287	16 02.0	25 23	8.24	G8 V	- 44.5	0.7	8	
7505	145374	07.5	27 06	8.28	K1 III	+ 6.4	1.5	4	

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
7507	145404	16 07.7	+26 08	9.20	G0 V	- 19.6	0.8	4	
7511	145458	08.0	25 37	8.67	G8 II-III	- 4.5	1.2	4	
7513	145457	08.0	26 52	8.14	K0 III	- 3.3	1.1	7	
7537	145890	10.3	26 34	9.15	K1 III	var?		4	II
7603	147487	19.2	27 29	9.15	G0 V	- 58.2	1.0	4	
7608	147527	16 19.4	+29 07	9.41	F5 IV	- 33.5	1.4	5	
7612	147665	20.2	24 52	9.50	F8 V	- 7.0	1.6	5	
7629	147980	21.9	28 30	8.80	K1 II-III	- 28.8	2.1	4	
7685	149067	29.4	25 57	9.26	G8 II	- 4.1	1.8	4	
7690	149132	29.7	29 43	9.25	K2 II	- 18.2	1.2	4	
7692	149142	16 29.8	+26 08	8.97	G8 III	+ 41.3	1.7	5	
7698	149241	30.4	27 49	9.49	K5 III	- 0.6	1.6	5	
7704	149403	31.5	24 59	9.33	G0 V	- 12.3	3.4	5	
7709	149474	32.0	25 35	9.65	K3 III	- 8.1	1.2	5	
7721	149803	33.9	29 51	8.90	F7 V	+ 1.2	0.7	4	
7734	150087	16 35.7	+27 28	9.24	G8 III	- 2.1	1.8	5	
7735	150086	35.6	28 56	9.74	G8 III	+ 1.1	1.0	4	
7737	150102	35.8	27 09	9.08	M2 III	+ 12.7	2.7	5	
7742	150205	36.3	29 46	8.32	G5 V	+ 29.9	1.5	4	
7756	150431	37.9	25 38	9.47	G8 III	- 14.0	0.8	4	
7761	150567	16 38.7	+29 01	9.13	K3 III	- 50.4	1.3	4	
7769	150665	39.5	26 11	9.14	K0 III	- 3.9	1.8	4	
7774		40.1	25 31	9.52	F7 IV-V	- 15.5	2.4	7	
7776	150799	40.2	25 31	9.79	F8 IV	- 28.7	2.9	5	
7779	150889	40.9	25 57	9.07	K2 III	- 54.4	1.6	4	
7799	151256	16 43.2	+24 40	9.57	K1 III	+ 10.5	1.1	4	
7806	151369	44.0	26 08	9.35	G2 IV	- 3.6	2.2	4	
7826	151625	45.4	28 29	8.82	G0 IV	- 38.4	2.4	4	
7833	151780	46.5	26 41	9.25	K1 III	- 19.9	1.2	4	
7847	152032	48.0	26 18	8.57	G8 II-III	- 19.5	1.9	4	
7857	152264	16 49.2	+29 39	8.41	G0 V	- 25.2	1.9	4	
7860	152306	49.5	28 12	8.23	G8 III	+ 6.0	1.1	4	
7884	152748	52.1	27 40	9.15	G8 II	- 13.7	2.4	4	
7908	153224	54.9	29 40	8.80	F8 V	- 17.4	1.4	4	
7940	153698	57.9	27 23	9.21	M III	- 20.1	1.3	5	
7956	154049	17 00.0	+25 06	9.41	K3 III	- 86.0	1.7	4	III
7969	154183	00.9	25 43	9.33	G0 V	- 21.7	2.4	5	
7973		01.1	24 55	9.51	K1 III	- 49.5	2.1	6	
7989	154510	02.8	28 10	8.59	K1 III	+ 2.5	1.0	10	
8001	154635	03.7	25 34	9.24	K0 II	- 49.0	1.0	4	
8009	154760	17 04.3	+26 35	9.31	G2 V	- 14.3	1.5	4	
8026	154942	05.5	28 11	8.77	K1 III	- 20.4	2.1	4	
8032	155041	06.0	29 13	9.13	K2 III	- 29.2	2.2	5	
8046	155344	07.9	26 31	8.50	K2 III	+ 4.0	0.9	4	
8063	155675	10.1	25 18	9.24	F8 V	- 23.8	1.7	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
8066		17 10.2	+29 35	9.48	G8 II-III	- 29.5	1.1	4	
8072	155839	11.2	25 03	9.18	K5 III	+ 0.8	0.8	5	
8073	155878	11.2	27 59	9.17	G8 II	+ 3.0	1.1	4	
8077	155989	11.9	26 14	9.43	G5 III	var.		5	II
8079	156002	12.1	26 53	9.10	F5 IV	- 9.7	3.6	5	
8084		17 12.2	+29 38	8.99	G0 V	+ 17.9	0.8	4	
8085	156093	12.5	26 07	8.42	K3 III	- 20.3	2.2	5	
8098	156362	14.0	27 11	8.27	K2 III	- 51.1	0.8	4	
8104	156454	14.6	26 38	9.41	G2 V	- 0.3	3.1	4	
8114	156563	15.3	25 05	9.56	G8 V	- 11.7	2.6	4	
8117	156652	17 15.6	+28 58	8.81	M III	- 36.4	2.0	5	
8127	156774	16.4	26 59	9.04	K2 III	- 48.3	3.1	5	
8128	156775	16.5	25 51	8.19	K1 III	- 4.8	1.4	4	
8135	156966	17.4	27 20	8.89	M2 III	+ 72.7	2.0	4	III
8152	157294	19.3	26 01	9.04	G8 III	- 48.6	3.1	5	
8189	158038	17 23.8	+27 21	8.76	K2 II	+ 15.6	0.9	4	
8207	158332	25.6	26 50	8.80	K1 IV	- 18.8	2.2	4	
8223	158521	26.8	26 46	8.82	F6 V	- 1.1	1.2	4	
8244	158823	28.3	29 33	9.25	K3 III	- 42.9	1.4	4	
8283	159479	31.9	26 42	9.56	K2 III	- 21.3	1.6	4	
8291	159608	17 32.4	+29 48	9.89	M2 III	- 60.2	3.2	6	
8309	159948	34.4	25 39	8.97	K2 III	+ 6.3	0.6	4	
8311	159968	34.4	27 36	8.44	M III	- 35.0	1.4	4	
8338	160508	37.2	26 47	8.91	F8 V	+ 25.1	1.8	4	
8350	160678	38.1	29 16	9.03	K0 III	+ 35.5	1.8	4	
8372	160952	17 39.7	+29 37	9.04	G8 III	+ 30.6	0.3	4	
8380	161112	40.6	26 34	8.82	K0 III	- 5.6	1.7	5	
8387	161197	41.1	24 49	8.91	G2 IV	+ 26.5	1.7	4	
8390	161196	41.1	29 40	8.96	M III	+ 2.4	2.0	4	
8392	161268	41.5	27 03	8.91	K1 II	- 23.4	2.4	4	
8492	162901	17 50.4	+25 00	8.95	K2 III	- 9.4	2.4	5	
8506	163077	51.3	25 00	8.82	G8 V	+ 12.3	1.3	4	
8523	163331	52.5	27 37	9.16	K1 III	+ 8.5	2.3	4	
8559	163949	55.6	28 00	9.39	F6 V	+ 16.5	1.5	4	
8563	163970	5.88	27 51	9.60	G0 V	- 28.3	2.8	4	
8564	163969	17 55.8	+28 15	9.52	G8 III	+ 8.0	2.2	4	
8569	164042	56.2	27 24	9.10	K2 III	- 25.9	1.8	5	
8571	164079	56.4	28 00	9.21	F2 V	+ 23.4	1.8	4	
8617	164923	18 00.4	25 00	9.80	K2 III	- 23.5	2.6	4	
8651	165473	03.0	29 05	8.29	K0 II	+ 18.7	1.4	4	
8654	165589	18 03.5	+28 41	8.31	K1 III	+ 11.5	1.1	4	
8656		04.0	25 41	9.09	F6 V	- 21.4	2.7	5	
8669	165989	05.5	26 24	8.22	G8 III	- 1.9	1.0	4	
8677	166070	05.8	27 23	9.33	K1 IV	- 27.6	1.4	4	
8683	166093	05.9	29 49	8.89	K3 II	- 25.0	1.6	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
8685	166181	18 06.3	+29 41	8.37	G5 V	var.		5	II
8706	166683	08.6	29 04	9.06	G8 III	- 17.5	3.0	6	
8707	166730	08.8	27 58	9.41	K1 III	- 29.0	1.0	5	
8709	166781	09.1	26 39	8.22	G5 III	- 34.9	2.0	4	
8712	166822	09.3	25 19	9.09	G0 IV	- 1.3	1.7	4	
8713	166842	18 09.5	+25 33	8.14	K1 III	- 59.3	1.8	4	
8715	166867	09.5	29 54	8.59	K0 IV	+ 17.3	1.2	4	
8716	166895	09.5	30 07	9.21	F6 V	- 20.7	2.2	4	
8717	166914	09.7	25 22	9.51	F8 IV-V	- 9.9	3.2	5	
8732	167132	10.9	25 38	9.46	K1 III	+ 11.6	1.0	4	
8742	167275	18 11.4	+26 14	8.79	K1 III	- 3.7	0.8	4	
8753	167472	12.2	28 12	8.19	K1 II	- 1.8	1.1	4	
8773	167782	13.7	25 47	9.70	G8 II	- 18.3	1.8	4	
8783	168038	14.8	27 05	9.07	F7 IV	+ 9.8	2.4	4	
8818	168622	17.6	27 28	9.70	K2 III	- 30.3	1.7	4	
8824		18 18.1	+26 29	10.87	K3 III	+ 8.7	2.4	4	
8836	168956	19.3	26 41	9.12	F6 V	- 25.3	2.1	4	
8849	169245	20.7	26 12	9.47	F8 V	- 13.4	2.1	4	
8870	169573	22.2	26 18	9.63	K2 III	+ 28.5	1.2	5	
8887	169797	23.3	26 03	8.92	G8 III	- 19.9	0.7	4	
8889	169819	18 23.5	+25 58	9.95	K2 III	+ 7.4	2.2	8	
8898		23.8	29 23	9.33	K2 II	- 3.4	1.2	4	
8958	170619	27.3	29 31	8.45	K0 III	- 26.7	1.0	5	
8975	170737	27.9	26 37	9.11	G5 V	-136.7	2.2	4	III
8976	170738	27.9	25 44	9.21	G8 III	- 27.8	2.1	4	
8990	170951	18 29.1	+25 08	10.05	M III	- 2.7	2.8	5	
9008	171164	30.0	28 51	9.61	K2 III	- 24.4	1.8	4	
9013	171232	30.6	25 27	8.66	G8 III	- 30.6	0.9	4	
9036	171550	32.4	29 42	8.00	K0 III	- 12.4	1.7	5	
9050	171830	33.8	27 10	9.41	G8 III	- 75.8	3.1	4	
9077	172132	18 35.3	+29 01	9.51	K2 III	+ 12.2	2.7	5	
9080	172169	35.5	29 32	8.39	K4 III	- 24.7	0.8	4	
9091	172311	36.4	28 15	9.82	G8 III	- 35.4	1.6	4	
9109		37.6	26 09	9.78	F8 V	- 37.6	2.7	4	
9180	173367	41.7	28 04	9.59	K0 III	+ 3.5	3.0	5	
9186	173435	18 42.2	+26 11	9.61	K0 III	- 3.3	2.8	5	
9223	173909	44.8	27 26	8.95	G8 III	+ 23.6	2.1	4	
9236		45.3	28 22	9.77	G0 V	- 68.3	1.9	4	
9244	174104	45.8	28 40	9.25	G0 Ib	- 14.3	3.0	4	
9245	174126	45.8	28 35	9.30	K2 II	- 9.2	2.8	5	
9263	174414	18 47.2	+27 40	8.46	K1 III	+ 14.8	1.6	4	
9288	174695	48.7	28 28	8.57	K1 III	+ 2.1	1.9	4	
9295	174764	49.1	29 40	9.77	K1 III	- 4.4	1.7	4	
9319	175036	50.4	26 28	8.94	G0 V	- 51.5	2.1	4	
9330	175204	51.3	25 19	8.93	G5 III	- 46.5	3.2	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
9358	175578	18 52.9	+29 58	8.77	G5 III	- 32.4	1.2	4	
9364		53.3	26 56	9.31	G8 III	- 4.1	2.2	5	
9383	175940	54.6	28 08	8.40	K2 III	- 31.3	2.2	4	
9417	176230	56.1	28 06	8.87	K1 II	- 45.2	2.2	4	
9449		57.4	29 32	9.01	F8 V	+ 10.4	1.1	4	
9459		18 57.9	+26 17	9.61	G8 III	+ 17.7	0.7	4	
9472	176695	58.3	28 36	9.17	G8 III	var.		5	II
9486		59.4	26 19	9.35	K1 III	- 2.1	1.1	4	
9516	177251	19 00.7	29 13	9.04	G8 III	+ 16.9	2.1	5	
9575	178029	03.9	29 15	9.19	G8 III	+ 11.4	1.6	4	
9585		19 04.5	+28 38	9.91	F8 V	+ 2.2	1.2	4	
9594		05.0	29 07	9.47	G2 V	- 7.8	1.4	4	
9607	178450	05.6	30 10	8.83	G8 V	var.		5	II
9629	178798	06.9	30 13	8.53	K3 III	- 12.1	0.9	6	
9659		08.6	28 16	9.29	F6 V	- 52.4	1.4	4	
9675		19 09.4	+26 19	8.83	G5 III	var?		5	II
9763	180502	13.7	29 02	8.77	G0 IV	- 4.3	1.1	4	
9797	181047	15.8	25 16	8.99	G8 V	- 84.6	1.5	4	III
9865	182056	19.7	30 16	9.25	K2 II	+ 7.8	1.5	4	
9877	182218	20.5	27 04	9.29	K1 III	- 7.3	2.5	5	
9882	182256	19 20.7	+25 14	8.94	F5 IV	- 57.4	2.4	5	
9929	182617	22.3	28 29	9.09	K1 III	+ 9.3	1.5	4	
9949		23.3	25 37	9.63	K1 II-III	+ 27.5	1.8	4	
9950		23.4	26 14	9.71	K2 II	- 59.7	1.0	5	
10014	183399	26.3	29 21	8.09	K1 III	- 13.5	1.0	5	
10039	183753	19 27.9	+28 37	9.59	K3 II	+ 26.7	1.4	6	
10072	184150	30.0	30 05	9.49	K3 III	- 30.0	0.4	4	
10077		30.4	25 19	9.45	pec.	- 4.2	0.3	4	N
10103	184538	32.0	25 42	8.97	K2 III	- 25.1	0.6	4	
10108	184590	32.2	25 15	9.27	M1 III	+ 28.3	1.0	6	
10122	184719	19 32.7	+29 03	9.31	K5 III	- 24.4	1.6	5	
10133		33.0	28 59	9.55	F7 V	- 37.0	0.4	4	
10151		33.6	30 17	9.73	G8 II	- 11.3	2.6	5	
10154		34.0	26 23	9.52	K1 III	- 52.9	2.5	4	
10175	185151	34.7	27 46	9.59	K1 III :	+ 4.4	3.6	4	N
10181	185270	19 35.2	+26 02	8.94	F8 V	- 25.5	1.3	4	
10182	185241	35.1	28 04	9.54	K0 III	- 36.5	1.0	4	
10184	185269	35.2	28 23	7.35	G0 IV	0.0	1.0	4	
10188	185289	35.3	26 15	8:41	G8 III	- 13.1	1.1	5	
10268	185982	38.7	27 37	9.29	G8 III	+ 8:1	3.1	4	
10292	186223	19 40.1	+27 04	9.47	K2 III	- 30.8	0.7	4	
10299	186260	40.3	26 57	9.24	K0 III	- 0.5	1.9	4	
10315		41.0	27 49	9.22	F8 V	- 19.1	1.2	4	
10333	186517	41.9	27 19	9.11	K1 III	- 37.6	1.3	4	
10377	186860	43.7	30 08	9.81	M III	+ 7.5	2.2	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
10414	187162	19 45.4	+28 22	9.47	G8 III	- 12.5	2.1	5	
10426	187280	46.2	28 12	9.51	K2 III	- 10.6	2.3	4	
10444	187462	47.1	27 37	7.71	G0 V	+ 3.5	0.5	6	
10445	187460	47.1	29 45	9.25	G8 III	- 6.1	2.7	6	
10454	187548	47.4	28 29	8.73	G0 V	+ 14.2	1.1	5	
10456	187565	19 47.5	+29 15	8.74	F8 V	var.		5	II
10465	187614	47.9	26 57	7.63	G8 III	var.		5	II
10499	187921	49.5	27 20	var.		var?		4	N, II
10509	188015	50.0	27 58	9.09	G5 IV	+ 2.6	0.7	4	
10528	188121	50.5	28 25	9.21	G0 IV	- 13.9	0.6	4	
10546	188259	19 51.2	+26 22	8.99	K1 III	- 26.9	1.4	4	
10548	188258	51.2	27 58	8.32	K2 III	- 35.3	1.1	4	
10582	188566	52.8	25 12	8.91	K2 III	- 9.5	2.2	5	
10601		53.3	29 51	9.36	K3 III	var.		5	II
10644		55.2	29 48	9.20	G0 V	- 9.6	2.7	4	
10646	189087	19 55.2	+29 41	8.73	K1 V	- 27.1	2.3	5	
10650	189108	55.4	28 34	7.83	G8 III	+ 10.2	1.0	5	
10668	189317	56.3	28 28	8.34	F6 V	- 35.4	1.7	4	
10704	189671	58.2	26 03	7.88	G8 II	- 20.9	0.3	4	
10713	189753	58.5	27 00	9.79	K4 II	- 8.0	1.0	4	
10724	189796	19 58.8	+29 41	8.46	G0 V	- 4.7	1.9	4	
10731	189884	59.2	27 03	8.90	K2 III	- 10.2	0.7	4	
10742	189943	59.5	30 05	8.70	G5 III	+ 17.6	1.6	4	
10753		59.9	29 45	9.45	F5 Ib	- 3.3	1.4	4	
10771	190228	20 00.9	28 10	8.36	G5 IV	- 48.7	0.4	4	
10799	190470	20 02.1	+25 39	9.04	K3 V	- 6.6	2.1	4	
10813		02.7	26 20	9.23	G0 V	- 43.8	2.5	4	
10814	190605	02.8	25 55	8.50	G2 V	+ 22.0	2.3	4	
10818	190630	02.8	30 22	9.39	K2 III	+ 16.5	1.1	4	
10831	190749	03.5	29 44	9.59	K1 III	+ 0.6	2.0	4	
10833	190787	20 03.7	+27 59	9.78	M III	+ 17.9	1.4	4	
10837		03.8	29 37	9.72	F6 V	var?		5	II
10838		03.9	29 37	9.20	K3 III	- 10.0	1.8	4	
10843	190885	04.1	27 59	9.84	K3 III	- 36.2	2.0	4	
10844		04.1	28 46	9.54	G0 V	- 16.3	1.4	4	
10850	191010	20 04.7	+25 32	9.42	G5 Ib	+ 21.9	1.1	4	
10899	191445	06.9	28 32	9.93	K3 III	+ 39.0	1.7	4	
10924	191590	07.7	29 35	9.28	K2 III	0.0	2.2	5	
10925	191615	07.8	25 23	9.09	K0 III	- 94.0	0.7	4	III
10961	191875	09.0	29 33	9.84	K3 III	- 25.0	2.0	4	
10962	191898	20 09.2	+25 59	9.56	G0 V	+ 11.4	2.3	4	
10971	191945	09.4	29 01	9.36	M0 III	- 17.4	1.4	4	
11011	192287	11.2	25 05	9.49	M III	- 7.3	2.6	5	
11012	192286	11.0	30 20	9.37	G8 III	- 75.9	0.8	4	
11015	192405	11.6	27 23	8.73	F7 V	- 24.3	1.7	4	

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
11036		20 12.7	+26 38	9.46	G5 III	- 23.1	1.9	4	
11053	192732	13.3	29 52	9.18	K0 III	- 11.1	2.8	4	
11072	192892	14.3	26 20	8.55	G9 III	- 17.1	1.2	4	
11086	193011	14.9	29 57	9.70	K1 III	- 29.9	1.1	4	
11110	193221	16.1	25 21	9.13	K2 III	- 11.4	1.6	4	N
11122	193347	20 16.7	+26 50	8.80	M2 III	- 36.7	1.2	4	
11140	193488	17.5	27 16	8.85	F6 IV	+ 10.3	3.4	5	N
11216	194071	20.5	28 05	9.06	G8 III	- 12.8	0.3	4	
11233		21.2	28 38	9.67	K1 III	+ 53.2	1.0	4	III
11254	194403	22.5	25 45	9.71	K3 III	- 2.8	2.8	4	
11271	194510	20 23.1	+25 33	8.90	F7 IV	+ 0.6	2.2	5	
11273	194525	23.0	30 24	9.04	G0 III	- 38.6	2.0	4	
11332		25.5	27 53	10.19	G8 III	- 14.7	1.9	4	N
11368	195216	26.9	27 41	9.95	K5 III	- 46.0	2.4	4	
11384	195273	27.4	26 46	8.85	K1 III	- 31.6	2.1	4	
11420		20 28.7	+27 47	9.66	K2 III	- 17.4	2.1	4	
11424	195509	28.8	26 31	8.58	K0 III	+ 2.7	1.9	4	
11440	195667	29.7	26 53	9.45	K3 III	+ 17.9	1.1	4	
11447	195712	29.9	26 54	9.45	K0 III	+ 7.8	1.7	4	
11453	195790	30.3	27 21	9.28	G8 III	+ 8.9	1.0	4	
11456	195834	20 30.6	+28 53	9.99	K3 II	- 3.5	1.2	4	
11470	195967	31.3	29 21	9.41	K2 III	+ 26.7	2.7	4	
11471		31.5	25 40	9.32	G8 III	+ 10.4	2.6	4	
11480	196034	31.8	25 27	9.82	K3 III	- 31.7	1.1	4	
11519		34.3	26 13	10.06	K1 III	- 55.9	0.5	4	
11525	196448	20 34.4	+29 02	9.60	G0 V	+ 4.6	1.1	4	
11546		35.5	30 00	9.31	G0 V	+ 21.5	1.9	4	
11571		36.8	26 31	9.74	G8 V	+ 3.9	0.8	4	
11573	196866	37.2	25 54	8.70	K2 III	- 76.5	1.0	4	
11579		37.4	26 27	10.21	K2 III	- 3.6	0.7	4	
11581	196928	20 37.4	+27 55	9.64	K4 III	- 17.9	2.6	5	
11584	196940	37.5	26 08	9.56	G8 III	- 6.0	2.4	4	
11598	197020	38.1	25 52	9.57	G0 V	- 6.1	1.6	4	
11623	197207	39.2	30 01	8.99	G5 V	- 52.5	0.5	4	N
11625	197227	39.3	29 09	8.73	F7 IV	+ 16.3	1.5	4	
11630	197264	20 39.6	+26 56	9.85	K0 III	- 0.9	1.8	4	
11631	197263	39.6	28 05	8.99	G0 V	- 2.4	1.7	4	
11648	197395	40.4	30 05	9.53	K2 III	- 7.6	1.3	4	
11661	197515	41.3	25 25	9.43	K5 III	- 46.8	0.6	4	
11662	197514	41.2	27 04	9.60	M III	- 19.2	1.7	4	
11663	197550	20 41.3	+30 02	9.81	K0 III	+ 9.8	1.4	4	
11668	197605	41.8	27 16	9.25	F5 II	- 13.7	0.9	4	
11755	198198	45.7	29 27	9.27	G8 III	+ 16.0	2.1	4	
11765	198238	46.1	26 13	9.90*	K5 III	+ 23.2	1.3	4	N
11767	198254	46.1	28 21	9.62	K1 III	- 15.0	3.0	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
11779	198313	20 46.5	+28 37	9.31	K1 IV	- 63.4	1.9	4	
11808	198483	47.6	25 35	8.55	G0 V	- 14.6	1.7	4	
11809	198482	47.5	30 28	9.54	K2 III	+ 15.8	2.2	4	
11814	198526	47.9	28 48	9.91	K1 III	- 0.9	1.1	4	
11817	198550	48.1	29 12	9.81	K5 V	- 13.3	1.0	4	
11823		20 48.4	+28 31	9.67	K0 III	- 7.2	1.8	4	
11855	198821	50.0	28 40	9.47	K2 III	- 23.0	1.4	4	
11919	199375	53.9	27 23	8.03	K2 III	- 12.8	1.6	6	
11923	199440	54.2	27 19	9.67	K1 III	- 45.1	0.9	4	
11941	199598	55.5	26 13	7.66	G0 V	- 27.1	1.3	4	
11958	199717	20 56.0	+29 05	9.57	K0 III	- 23.8	2.0	4	
11965	199763	56.2	30 12	7.67	G9 III	var?		5	II
11970		56.3	30 26	9.93	G0 IV	- 26.6	0.8	4	
11990		57.8	29 05	9.75	F8 V	- 2.2	2.3	4	
12015		59.6	27 03	9.77	G0 IV-V	- 9.0	2.1	5	
12031	200391	21 00.3	+27 37	9.11	G0 III	var.		54	II
12032	200425	00.4	25 58	8.42	F8 V	- 24.9	1.1	4	
12035	200451	00.5	26 19	9.49	K5 III	- 29.7	1.9	4	
12042	200491	00.8	28 47	8.96	G8 III	- 5.2	0.4	4	
12050	200546	01.2	27 08	9.58	M2 III	- 18.0	1.3	4	
12059	200578	21 01.4	+28 54	8.05	G8 III	- 25.0	0.5	4	
12069	200679	01.9	26 09	9.76	K1 III	- 16.3	1.5	4	
12130	201094	04.5	26 21	9.94	K2 II	+ 3.8	1.1	4	
12135		04.7	30 15	9.92	K0 III	- 21.3	1.9	4	
12158		05.6	30 10	9.38	G0 V	- 12.7	1.8	4	
12166	201346	21 06.0	+28 25	9.46	K1 IV	- 71.0	2.0	5	
12185	201490	07.0	30 10	8.57	F7 V	+ 1.0	0.8	4	
12199	201626	07.8	26 25	9.53	pec.	-150.8	0.7	15	N, III
12205	201669	08.1	27 06	8.94	G8 III	+ 5.9	0.3	4	
12228	201860	09.4	26 08	9.48	G0 V	- 36.2	1.2	4	
12281	202365	21 12.4	+27 57	9.01	K0 III	- 10.8	2.9	4	
12296	202521	13.4	27 48	9.13	K2 III	+ 15.5	0.7	4	
12298	202573	13.7	25 14	8.16	G5 V :	- 28.4	0.9	4	
12352	203030	16.8	26 01	7.30	G8 V	- 12.9	1.9	4	
12372	203171	17.6	27 18	9.02	G0 V	- 17.9	1.4	4	
12381	203288	21 18.4	+26 02	9.38	K5 III	+ 16.7	2.0	4	
12385		18.5	29 55	9.62	K1 III	- 47.1	0.6	4	
12398		19.0	30 04	9.77	K2 III	- 7.4	2.9	5	
12402	203471	19.4	28 21	9.38	G5 V	+ 18.9	2.2	4	
12426		20.5	30 28	9.53	K0 III	- 1.8	0.8	5	
12442	203733	21 21.1	+29 36	9.08	K1 III	- 46.7	1.4	4	
12483	204079	23.3	27 00	9.43	K1 V	- 30.9	1.5	4	
12514	204388	25.3	27 39	9.58	K5 III	- 24.7	0.6	4	
12538	204539	26.5	26 12	9.21	K3 III	- 44.8	0.7	4	
12539	204540	26.5	25 42	8.44	K2 III	- 23.7	0.5	5	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
12553	204642	21 27.1	+28 22	8.14	K2 III	+ 19.9	0.4	4	
12554	204658	27.2	28 39	9.42	G0 V	var?		5	II
12566	204711	27.6	25 36	9.68	K2 III	- 15.8	1.6	4	
12592	204923	28.9	25 50	9.89	K3 III	- 23.0	2.0	4	
12596	204934	29.0	28 09	9.64	K1 III	+ 2.5	0.3	4	
12598	204921	21 29.0	+30 03	9.18	K2 III	- 25.7	2.0	4	
12643	205287	31.4	27 23	9.98	K5 III	- 41.7	0.8	4	
12644	205316	31.6	25 40	9.61	K0 III	- 17.2	1.5	4	
12677		33.1	27 48	9.52	G0 V	- 21.1	1.0	4	
12691	205626	33.7	26 09	9.95*	F8 V	- 2.7	1.1	4	
12692	205627	21 33.7	+26 09	9.98*	F8 V	- 8.7	1.6	4	
12704	205700	34.2	29 19	8.78	F5 V	- 7.5	1.9	5	
12707		34.5	29 27	9.36	G8 III	+ 0.3	2.6	5	
12709	205760	34.7	25 23	9.84	K1 III	- 10.6	1.7	4	
12781	206332	38.5	28 32	8.24	G0 V	- 42.8	0.8	4	
12786	206374	21 38.8	+26 31	8.51	G8 V	- 41.1	1.2	4	
12787	206373	38.8	29 07	9.08	G0 V	- 91.8	1.7	4	III
12789	206385	38.8	30 04	9.12	K5 III	+ 13.2	1.6	4	
12834		41.9	26 17	9.36	G2 V	- 45.2	1.2	4	
12842	206889	42.2	29 02	8.56	K1 III	- 8.1	0.8	4	
12846	206899	21 42.2	+30 05	10.00	K5 III	+ 5.1	2.1	4	
12854	206978	42.9	30 11	9.65	G0 IV	- 12.5	1.9	4	
12856	206979	43.0	29 00	9.41	K2 III	- 73.4	1.4	4	
12885	207243	44.7	29 52	9.62	K0 III	+ 11.9	1.9	4	
12902	207379	45.6	29 30	9.12	K1 III	- 4.2	2.0	5	
12915	207470	21 46.3	+28 29	9.58	G8 III	- 0.9	1.9	4	
12947	207740	48.4	28 32	8.96	G5 V	+ 8.5	1.3	4	
12985	208277	52.3	30 00	9.52	G5 III	var.		5	II
12998	208379	53.2	25 42	9.41	G0 V	var?		5	II
13000	208415	53.2	30 35	9.04	K0 III	- 0.2	1.5	4	
13008	208457	21 53.6	+26 10	9.29	G0 IV	- 3.6	2.2	4	
13020		54.1	26 13	9.64	G5 V	- 33.1	1.8	4	
13032	208641	54.9	27 45	9.61	G0 III	+ 1.4	2.1	4	
13037	208658	55.0	28 35	9.47	K1 III	+ 15.1	1.1	5	
13039		55.2	28 42	9.76	G5 V :	- 16.8	0.9	4	
13040	208700	21 55.2	+29 04	8.84	K3 III	- 13.1	0.5	4	
13047	208750	55.6	26 59	9.58	G0 IV	- 63.6	4.0	5	
13070		57.0	28 24	9.76	G0 V	- 35.5	1.8	4	
13072	208951	57.0	30 18	9.24	K2 III	- 20.7	0.3	4	
13076	208987	57.2	29 39	9.94	K5 III	var?		5	II
13135	209457	22 00.7	+29 27	10.21	K5 III	- 7.3	2.2	5	
13140	209500	01.1	29 30	9.92	K5 III	+ 15.9	0.9	4	
13144	209543	01.3	26 42	9.49	K0 III	- 5.9	0.9	4	
13147	209598	01.7	28 06	var.	M III	- 19.4	0.8	4	N
13157	209680	02.3	29 43	10.26	K5 III	- 5.6	1.8	6	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
13167		22 02.9	+25 25	9.71	F8 V	- 4.8	2.8	6	
13169	209745	02.9	29 37	9.38	F8 V	- 21.8	0.8	4	
13179	209858	03.6	27 44	8.59	F8 V	+ 0.6	1.5	6	
13188	209994	04.5	28 04	9.94	K0 III	+ 10.5	1.0	4	
13192	210026	04.7	26 23	8.79	K1 III	+ 14.0	0.8	4	
13194		22 04.8	+26 48	10.08	K5 III	- 21.5	1.6	8	
13246		08.6	25 34	9.93	K3 III	- 2.0	2.4	4	
13250	210608	08.7	29 24	9.87	K0 III	+ 8.5	1.6	4	
13262	210685	09.3	27 01	9.52	K1 III	+ 18.3	1.3	4	
13271	210789	10.1	25 14	9.52	K2 III	- 43.8	0.6	4	
13283	210925	22 10.9	+25 42	8.05	K0 III	- 62.4	1.3	6	
13325	211407	14.0	26 01	9.49	K0 III	+ 5.4	0.5	4	
13331	211460	14.4	28 55	9.02	G8 III	var.		5	II
13340	211555	15.1	26 08	8.62	K0 III	- 23.4	0.3	4	
13344	211606	15.5	26 41	8.90	K5 II	- 8.3	1.0	4	
13366	211884	22 17.6	+25 28	9.46	K5 III	- 23.8	2.6	5	
13391	212280	20.3	30 06	8.59	G0 IV	var.		4	N, II
13393	212289	20.4	30 30	9.49*	K1 II	+ 5.0	1.4	4	
13422	212567	22.5	28 26	9.68	K0 III	- 19.3	1.7	6	
13439	212750	23.8	28 16	8.57	K1 III	+ 1.4	0.3	4	
13466b	213025	22 25.8	+26 46	7.92	G8 III	- 39.7	1.7	5	
13477	213177	26.7	29 32	9.17	K0 II	- 2.3	0.6	4	
13479	213178	26.8	28 46	8.75	K1 III	- 7.5	0.8	4	
13518		30.0	25 20	9.50	G8 II	var.		5	II
13532	213803	31.3	29 20	9.34	K0 III	+ 13.2	1.6	4	
13540	213857	22 31.7	+29 29	9.58	K0 III	- 39.0	1.1	5	
13547	213947	32.3	26 20	8.93	K4 III	+ 20.0	0.4	4	
13552	213992	32.5	29 42	8.67	K3 III	+ 7.7	1.6	4	
13555	214023	32.7	30 33	9.20	K3 III	- 38.0	1.4	4	
13568		33.4	29 51	9.44	G8 III	var?		7	II
13570	214202	22 33.9	+29 29	9.63	G8 III	- 1.8	2.8	4	
13575	214265	34.3	27 31	8.49	K0 III	- 17.7	0.3	4	
13583	214332	34.6	29 29	9.32	G8 III	- 12.3	2.6	5	
13592	214434	35.6	26 10	9.17	K2 II	- 1.4	2.1	5	
13596	214458	35.6	29 40	8.72	K2 III	- 41.6	0.7	4	
13639		22 39.1	+29 47	9.92	K3 III	- 37.7	1.8	4	
13664	215274	41.3	29 50	8.91	G5 V	- 11.6	0.8	4	
13675	215360	41.9	29 21	9.58	M III	- 64.6	1.4	4	
13705	215732	44.6	29 39	9.27	K3 III	+ 0.5	1.0	4	
13715	215944	46.1	27 51	9.00	F8 V	+ 3.4	0.8	4	
13716	215956	22 46.2	28 28	9.10	G0 V	- 17.4	1.6	5	
13748	216331	49.4	29 47	8.75	G5 II	- 9.8	1.1	4	
13758	216465	50.4	29 11	8.81	F5 V	0.0	1.3	5	
13760	216502	50.8	26 43	8.86	K2 III	- 9.8	1.0	4	
13769	216586	51.4	28 22	8.84	K1 III	- 50.4	1.4	4	

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec)	P.E.	Pl.	Ref.
13772	216632	22 51.8	+27 45	8.29	F8 V	- 17.7	1.4	4	
13777	216685	52.2	29 06	9.30	F8 V	- 9.2	1.0	4	
13780	216723	52.5	27 45	8.36	G8 III	- 15.2	0.5	6	
13813	217230	56.5	27 14	9.14	G8 III	+ 17.8	0.7	4	
13821		57.1	29 49	10.21	G5 V	var?		4	II
13839	217576	22 59.0	+28 26	9.24	K0 III	var.		6	II
13850		23 00.3	28 56	9.60	G2 V	+ 3.1	3.2	5	
13862		01.8	28 34	9.42	G2 V	var?		5	II
13863		01.9	27 33	9.82	G0 IV	- 37.6	1.5	4	
13870	218113	02.7	27 56	9.64	K5 III	- 20.8	2.5	6	
13876	218153	23 03.1	+25 44	9.07	G8 II	- 80.5	1.1	5	III
13877	218170	03.1	28 43	9.18	M2 III	- 56.4	1.4	4	
13879	218199	03.3	30 27	9.43	K1 II	- 6.0	0.4	4	
13894	218356	04.7	25 12	6.53	K1 II-III	- 25.3	1.1	4	N
13901	218454	05.4	30 10	9.03	K4 II	- 19.2	0.6	4	
13910		23 05.9	+30 11	9.30	G8 III	- 6.9	0.9	4	
13919	218610	06.7	26 39	9.34	K2 III	- 3.3	1.5	7	
13923	218660	07.1	29 24	8.10	K2 III	+ 11.2	0.9	5	
13940	218880	08.8	29 46	8.30	K0 III	+ 41.9	1.0	4	
13990b	219418	12.9	25 24	9.52	G5 III	+ 39.6	0.7	5	
13996	219538	23 13.8	+30 24	9.04	K2 V	+ 10.0	1.6	4	
14006	219654	14.9	29 36	9.32	M1 III	+ 3.3	1.6	6	
14015	219736	15.5	30 11	8.41	K2 III	- 3.8	1.3	7	
14021	219800	16.0	27 20	8.29	K0 III	var.		5	II
14059	220286	19.9	29 10	9.28	G0 IV	- 16.1	1.0	5	
14060	220288	23 20.0	+25 39	8.38	K3 III	+ 25.8	1.8	4	
14084	220684	23.1	25 55	9.26	G8 III	+ 0.1	2.3	7	
14120	221133	26.9	25 32	9.26	K2 III	- 22.9	1.4	4	
14121	221170	27.0	30 09	9.04	G0 V	-119.8	3.0	4	III
14136b	221364	29.0	28 23	7.02	K0 III	- 4.0	1.2	4	
14142	221469	23 29.8	+26 17	8.98	F8 IV-V	- 14.8	0.6	5	
14144	221478	30.0	26 15	9.18	G8 II-III	+ 22.0	2.0	4	
14180	222033	34.6	30 24	8.02*	G0 V	- 12.6	0.8	4	
14185		34.8	25 30	9.97	G8 III	- 11.8	2.1	5	
14190		36.3	25 40	9.76	K1 III	- 4.6	0.9	4	
14195b	222317	23 37.0	+27 58	7.95	G5 V	var.		6	II
14201b	222390	37.5	27 14	8.00	K1 III	- 11.4	1.0	4	
14203	222391	37.5	26 31	8.34	G0 III	- 2.1	0.5	4	
14232		41.3	30 27	9.70*	G0 V	+ 6.4	2.1	4	
14255	223019	43.2	26 04	9.40	K3 III	- 11.2	1.0	4	
14261	223094	23 43.9	+28 26	8.97	K5 III	+ 20.8	0.5	4	
14267	223138	44.3	28 09	8.55	M III	- 1.7	0.9	4	
14276	223211	45.0	25 18	7.3	K3 III	- 18.3	0.6	4	
14279	223231	45.1	26 54	9.69	K2 II	- 6.3	1.6	4	
14292	223332	46.1	28 06	9.06	K5 II	+ 11.8	0.8	4	

TABLE I - continued

A.G.	H.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
14301	223424	23 46.8	+26 45	9.01	K0 III	+ 4.8	2.7	6	
14333	223869	50.6	25 43	8.67	K1 III	+ 16.7	1.7	4	
14346	224085	52.5	28 21	8.71	K2 III	var.		7	N, II
14376	224458	55.5	29 42	9.52	G8 III	- 55.2	1.0	6	
14406	224882	58.9	30 27	8.44	G0 IV	- 14.5	1.1	5	
14407	224895	23 59.0	+28 09	8.16	K2 III	- 11.4	1.7	4	

NOTES TO TABLE I

A.G. 2298 The spectrum is composite; the hydrogen lines of the A-type spectrum are very broad as are also some of the metallic lines. The velocity refers to the F-type spectrum.

A.G. 3518 CN λ4215 is weak as in the spectra of high-velocity stars.

A.G. 3918 The spectrum has been reported as composite (Ap. J., vol. 112, p. 48, 1950). It is apparent on our plates.

A.G. 4671 Refers to south preceding component of H. D. 74348.

A.G. 4875 The star has a very close fainter companion.

A.G. 6501 The lines are very diffuse.

A.G. 6821 RX Boo. Hydrogen emission lines.

A.G. 6861 The lines are diffuse. The strength of the hydrogen lines suggests type F0 and the strength of λ4077 suggests brighter than class V. Other features are contradictory and vary from one plate to another.

A.G. 10077 The hydrogen lines and the lines near λ4250 indicate F0 type or earlier. The iron lines, λ4227 and the G band indicate F6.

A.G. 10175 Ca II emission appears on one plate. The plates are poor and there is uncertainty about the luminosity.

A.G. 10499 SV Vul, a known Cepheid. The classification from our plates ranges from F8 Ib to G5 Ib.

A.G. 11110 Two plates give K2 III; a third gives G8 III.

A.G. 11140 One plate gives luminosity II.

A.G. 11332 The south preceding component of a pair.

A.G. 11623 The south following component of a pair.

A.G. 11765 ADS 14315. The data refer to the brighter component.

A.G. 12199 A CH star. (See Jour. Roy. Astr. Soc. Can., vol. 47, p. 65, 1953).

A.G. 13147 TW Peg.

A.G. 13391 One plate shows double lines.

A.G. 13894 56 Peg. Ca II emission and strong hydrogen lines have been recognized. (See L. O. B., vol. 6, p. 149, 1911).

A.G. 14346 A known spectrographic binary with Ca II emission and weak hydrogen lines. (See Jour. Roy. Astr. Soc. Can., vol. 46, p. 103, 1952).

Column 7 gives the mean radial velocities. When the designation "var." appears, it means that the data strongly suggest variable velocity; "var?" means that variable velocity is less strongly suggested. Assignment of these classifications has been made on the basis of a statistical treatment of the data as described earlier. For both "var." and "var?" stars, no mean velocities are given, but the individual velocities are listed in Table II.

Column 8 gives the probable errors of the mean velocities derived from the individual plate velocities in the usual manner.
Notwithstanding the remarks made with reference to column 7, one can expect that a number of the stars with probable errors in excess of 2 km./sec. are variable in velocity; but it is not possible to say which ones with any degree of confidence.

Column 9 gives the numbers of plates used for the velocity determination.

Column 10 refers to inclusion in a series of notes following the table (N) or to inclusion in Table II (II) or in Table III (III).

Stars with Variable Velocity (Table II)

In Table II are listed the individual velocities, along with the Julian Days of the observations, of those stars which, on the basis of the statistical criteria mentioned earlier, have been listed in Table I as having certain or almost certain velocity variations (var.) or as having less strongly suggested variations (var?). There are 43 of the former and 31 of the latter. In two instances where many observations are at hand and an orbit will be published soon, the individual velocities are not listed.

High-Velocity Stars (Table III)

On the basis of radial-velocity data alone, it is possible to classify a number of the stars as high-velocity stars. Table III lists all the programme stars, 31 in number, for which the radial velocities, after correction for solar motion (Apex 18h, +30°; velocity 20 km./sec.), exceed 65 km./sec. Sixteen of these stars (marked *R*) have been listed by Miss Roman in her recent *Catalogue of High Velocity Stars* (1955).

Earlier Publication of Some of the Radial Velocities

Radial velocities of 223 of the stars included in this report were reported in 1950, when the data were less complete, to R. E. Wilson and were included by him in his *General Catalogue of Stellar Radial Velocities* (1953). The velocities given in Table I differ in a number of cases by one or two km./sec. from the velocities reported in

Wilson's *Catalogue*, either because of the effect of subsequent observations or by virtue of different weighting. Aside from these small differences, the corrections to Wilson's *Catalogue* are as follows.

The following stars, reported as spectroscopic binaries in Wilson's *Catalogue* are now, as a result of more careful analysis, believed to have constant velocity: A.G. 366, 382, 444, 647, 714, 983, 2157, 2714, 2845, 3240, 4051, 6808, 6983, 7155, 7468, 7989, 9629, 13283, 13870, 13918, 14015, 14060, 14084.

A.G. 628 reported in Wilson's *Catalogue* as having constant velocity is now believed to be probably variable in velocity.

The velocity assigned to star number 14428 in Wilson's *Catalogue* (B.D. 29° 4828) really belongs to A.G. 13821 (B.D. 29° 4830).

Acknowledgments

As well as to those whose names appear in this report, the writer wishes to offer sincere thanks to the members of the Observatory staff for the many hours of observing, measuring and computing which have been put into this work over the past ten years. Thanks are also due to Dr. W. W. Morgan of the Yerkes Observatory and to Dr. Nancy Roman of the U.S. Naval Research Laboratory for advice in the matter of spectral classification.

References

Johnson, H. L. and Morgan, W. W. 1953, *Ap. J.*, vol. 117, p. 318.

Roman, Nancy G. 1955, *Ap. J. Supp.*, vol. 2., p. 198.

Schlesinger F. and Barney I. 1933, *Trans. Astr. Obs. Yale*, vol. 9.

Weatherburn, C. E. 1949, "A First Course in Mathematical Statistics", 2nd Ed., Cambridge University Press.

Wilson, R. E. 1953, *Carnegie Inst. of Washington Pub.* 601.

Richmond Hill, Ontario,
June 5, 1956.

TABLE II

Stars with Variable Radial Velocity

Star A.G.	Julian Day (243 . . . .)	Velocity (km./sec.)
14436	2066.801	+ 1.9
	2422.814	+13.6
	3186.752	+21.9
	3197.722	+14.8
	3515.875	+18.6
	3542.761	+14.9
188	2780.829	−23.8
	2850.639	− 6.8
	3151.834	−27.1
	3189.704	− 0.4
	3554.744	−19.4
	3576.674	−23.0
230	2772.854	−27.1
	2823.720	−22.2
	3169.772	− 0.3
	3228.622	− 0.9
	3568.686	−25.9
	3608.597	−21.9
	4041.527	− 6.0
434	2784.844	−11.1
	2823.741	−13.7
	2826.745	−22.4
	3181.790	−17.2
	3571.697	+ 5.3
	4651.803	−19.8
628	2529.567	− 3.5
	2804.822	− 7.8
	3162.850	− 4.6
	3175.778	−20.2
	3584.717	−29.6
	3940.772	−42.3
	4651.856	−30.4
706	2491.673	−14.2
	2806.819	−45.8
	2823.760	−57.6
	2828.742	−54.6
	2841.710	−53.2
	3570.729	−24.4
	3960.682	−14.6
	4652.715	−15.5
1192b	2079.853	+ 7.6
	2203.525	+19.7
	2429.836	+16.0
	3197.846	+17.4
	3556.831	+30.6
1301	2568.531	− 2.4
	2895.612	+ 6.4
	3159.893	+18.3
	3325.562	+ 7.5
	3581.790	+14.5
	3710.538	−42.9
1584	17 plates. Double lines An orbit will be computed	
1758	2112.805	−44.2
	2453.891	−87.7
	2467.858	−52.6
	2591.510	− 4.6
	3554.897	+61.1
	3587.785	+58.5
2344	2120.862	− 7.2
	2129.853	−20.5
	2883.751	− 5.8
	3008.546	− 9.9
	3575.900	+ 1.6
3194	2839.944	+ 6.6
	3229.837	+11.2
	3316.652	−20.1
	3352.528	+ 6.8
	3710.611	+30.6
	4667.710	+ 4.3
3204	2140.842	+ 5.5
	2203.694	+ 1.2
	2461.935	+24.4
	2143.847	+ 1.8
	3315.716	+11.4
3471	3603.868	+102.0
	3935.937	+84.2
	3937.881	+48.7
	3955.866	+54.5
	4668.745	+41.7
	4676.776	+63.9
3918	2144.895	− 0.8
	2639.546	+46.6
	4311.955	+ 0.1
	4347.711	+ 0.5
	4391.844	− 0.4
	4394.802	+23.7
	4501.587	+22.8

Star A.G.	Julian Day (243 ....)	Velocity (km./sec.)
3980b	2169.822	+32.8
	2283.562	+19.2
	3644.776	+19.7
	4062.600	+36.3
4209	2203.781	−24.8
	4080.606	−27.6
	4132.555	− 1.4
	4133.556	−26.7
	4833.615	−14.2
4384b	2139.822	+ 1.9
	2165.870	+18.3
	2202.760	+17.5
	2257.641	+14.9
	3320.730	+28.9
	4736.664	+26.9
4451	2644.556	−38.8
	3664.750	−38.3
	4668.879	−25.8
	4746.658	−54.0
4526	2624.614	+34.1
	2982.622	+45.2
	3681.751	+64.8
	4750.633	+22.6
	4791.527	− 4.1
4632	2888.900	−30.2
	2968.681	−23.5
	4765.676	−49.3
	4791.733	−26.8
4702	2587.765	− 3.2
	3281.833	+ 2.6
	4699.965	− 2.6
	4777.608	+25.3
4834	2899.917	+27.2
	4099.630	+ 6.3
	4771.837	+ 1.0
	4793.644	+11.8
5038	2888.921	+18.6
	2977.727	− 3.2
	4705.920	+35.7
	4800.647	−16.2
	4841.556	+13.4
5059	2573.819	+42.9
	2974.726	−13.3
	3763.597	+20.0
	4809.794	−34.4
5145	2615.718	− 0.1
	3687.765	− 9.0
	4785.835	−28.5
	4818.601	−12.7
5179	2391.836	+83.9
	3035.556	+101.9
	4719.958	−17.0
	4813.699	− 6.9
5229	2639.670	+ 6.2
	3015.630	−23.0
	4792.783	− 0.4
	4828.606	− 9.2
	4833.702	− 3.9
5254	2989.676	−34.3
	3344.767	−17.3
	3398.625	−10.1
	4134.625	−31.0
	4434.578	−50.7
5355	3693.788	+23.7
	3743.645	− 7.1
	4813.841	−16.4
	4819.769	−16.8
	4841.634	−20.6
5356	2672.561	−24.4
	2675.580	−16.5
	3771.572	+ 5.0
	4132.708	−20.6
	4844.576	−27.8
5591	2275.688	−12.6
	3322.847	+16.9
	4755.849	−13.0
	4828.757	+33.2
	4833.739	−33.6
5922	3010.700	−32.1
	3692.882	−29.2
	3775.638	−16.7
	4165.710	+ 0.4
	4557.624	−21.5
	4796.803	−42.7
6134	3011.716	−33.0
	3381.729	−18.0
	4080.817	−14.9
	4186.604	− 6.4
	4755.926	−30.8

Star A.G.	Julian Day (243 ....)	Velocity (km./sec.)
6313	2275.783	− 5.5
	3037.681	−16.6
	3779.649	+ 9.3
	4132.674	+ 9.4
	4188.679	− 7.6
6478	3036.700	+15.9
	3425.638	+30.7
	4086.851	+ 3.0
	4198.668	− 6.1
	4226.592	+ 1.1
6501	3053.652	−42.6
	3393.762	− 6.8
	4126.724	+16.2
	4228.592	+16.6
	4235.585	−14.3
	4501.738	−31.8
	4507.672	−53.2
6618	2982.868	− 1.9
	3028.727	−13.2
	3423.685	+36.5
	4162.744	−24.2
	4210.622	−19.7
	4796.940	−14.2
6694	2639.811	−19.2
	3033.734	−52.8
	3370.855	− 6.9
	3718.866	+10.0
	4195.712	−41.5
6832	2720.606	+14.2
	3037.744	− 4.3
	3380.795	+22.2
	3426.692	−16.0
	3470.639	+10.6
	3490.583	+ 4.6
	4536.747	+ 3.4
6861	2703.682	−12.7
	3028.776	+59.2
	3731.842	+13.2
	3757.770	+49.7
	4188.724	−23.3
7079	2949.961	−18.1
	2977.918	+ 2.5
	3034.760	− 2.4
	3098.612	+ 5.2
	4565.667	+10.7
	4918.883	− 1.3
7106	2369.650	−30.3
	2994.869	+ 2.0
	3057.703	−41.2
	3080.640	−22.0
	3434.694	−20.0
	4126.804	−40.0
7181	2303.793	− 0.4
	2718.644	−21.6
	3061.710	−21.7
	3423.724	− 0.7
	3490.608	−16.2
	4111.846	+ 9.2
	4482.803	− 9.9
	4504.803	+ 5.7
	4525.713	−11.4
7353	2737.624	−43.1
	3031.760	−26.8
	3079.671	−49.0
	3413.785	− 9.3
	4569.673	−44.5
7419	3015.865	− 9.3
	3057.757	+50.4
	3086.675	+11.2
	3757.829	−39.6
	3822.651	+12.4
	4819.928	−52.8
7444	2722.672	+ 8.2
	3053.747	−13.0
	3404.816	+18.5
	3409.804	+12.1
	3821.654	+12.1
7537	2712.717	+23.8
	3033.815	+36.9
	3061.746	+12.0
	3067.726	+21.0
8077	2728.751	− 2.6
	3023.893	−17.9
	3044.839	+25.3
	3840.652	−19.7
	4218.688	−17.8
8685	2760.665	−56.3
	3136.587	−31.2
	3507.653	−32.7
	3772.875	+30.8
	4303.521	+29.4

Star A.G.	Julian Day (243 ....)	Velocity (km./sec.)
9472	2765.690	+13.0
	3067.837	+14.1
	4195.774	−10.2
	4284.650	−19.4
	4603.704	− 3.8
9607	2347.796	+ 3.2
	3094.843	+12.5
	3098.758	− 2.9
	4173.849	−52.4
	4513.856	+ 8.9
9675	2426.646	−19.2
	2744.745	−18.6
	3833.753	−45.2
	4199.724	−34.4
	4548.767	−35.0
10456	2765.740	−24.6
	3144.662	−31.0
	3571.509	− 1.9
	4567.786	−23.8
	4636.545	−34.5
10465	2098.549	−10.5
	2262.844	− 5.8
	2480.991	− 6.0
	3515.670	−21.1
	4583.741	− 7.1
10499	2790.660	− 4.9
	3150.639	−10.2
	4275.615	− 6.6
	4569.745	+15.7
10601	2772.689	− 7.1
	2835.523	−13.4
	3154.582	+23.2
	4225.755	−13.9
	4582.788	+11.1
10837	3141.785	−11.4
	4273.628	−39.8
	4583.769	−26.2
	4612.700	−12.6
	4638.537	−22.3
11965	2028.789	−55.3
	2066.690	−55.3
	2079.660	−57.4
	3508.731	−44.8
	4699.494	−41.6
12031	54 plates. Double lines. An orbit is being computed	
12554	2792.718	− 9.0
	3178.665	−18.4
	4209.824	−19.0
	4618.778	+ 2.9
	4756.476	−39.7
12985	2798.812	−13.2
	3121.307	+ 5.6
	3945.588	− 8.2
	3962.606	+21.2
	4610.781	+ 4.7
12998	2793.698	−35.1
	3585.544	−11.7
	3945.615	−38.2
	3962.564	−11.3
	4629.717	−20.6
13076	2798.710	−46.6
	3202.610	−37.4
	3897.699	−20.3
	3941.654	−23.8
	4629.671	−21.7
13331	2066.757	−37.9
	2067.738	−37.6
	2068.726	−33.3
	3509.746	−19.8
	3857.865	−33.8
13391	2390.838	+30.8
	2748.855	+11.3
	3130.816	+ 4.7
	3883.795	{−39.4 +40.3
13518	2788.749	+ 5.7
	2864.538	− 4.6
	3150.751	+12.3
	3532.714	+30.4
	3919.709	+22.0
13568	2779.781	+ 1.8
	2785.762	− 3.2
	2841.610	+ 8.9
	3555.683	+19.9
	3996.473	− 9.8
	4266.740	+18.6
	4277.694	+ 9.8

Star A.G.	Julian Day (243 . . . .)	Velocity (km./sec.)	Star A.G.	Julian Day (243 . . . .)	Velocity (km./sec.)
13821	4912.828	−15.6	14021	2454.739	−20.7
	4972.822	−43.1		3136.840	−45.8
	4974.819	−36.2		3199.685	−23.8
	5008.718	−20.0		3541.723	−20.3
				3955.626	−10.7
13839	2785.765	+ 0.8			
	3530.792	+24.9	14195b	2101.692	−18.9
	3532.743	+34.2		2109.711	−35.6
	3884.778	+ 9.7		3129.840	+32.6
	3970.615	+19.5		3190.702	+31.1
	4269.782	+ 0.3		3514.819	+20.2
				4659.578	− 0.9
13862	2765.838	+26.5			
	2820.685	+ 1.2	14346	2100.726	−46.7
	3170.716	+12.0		2873.563	−34.2
	3222.621	−12.0		3149.832	−37.5
	3982.549	+ 3.9		3199.728	− 5.4
				3507.878	−36.8
				3542.747	+ 3.3
				4266.702	−54.2

TABLE III

HIGH-VELOCITY STARS

A.G.	V* km./sec.	A.G.	V* km./sec.
486 *R*	−160.7	5055 *R*	+ 85.1
991	− 67.1	5122	+ 67.2
1264	− 68.4	5787	+ 89.6
1528	− 68.3	6838 *R*	−116.5
1572 *R*	+ 79.1	6848	− 69.4
2248 *R*	− 78.5	7956	− 66.7
2302 *R*	− 72.5	8135	+ 92.4
2845 *R*	+ 87.3	8975 *R*	−116.8
3146 *R*	−115.1	9797	− 65.6
3668 *R*	+ 84.4	10925 *R*	− 76.4
3866 *R*	+ 99.3	11233	+ 70.5
4051 *R*	−144.7	12199	−135.7
4194 *R*	+ 71.9	12787	− 78.0
4809	+ 82.4	13876	− 72.2
4814 *R*	+ 98.0	14121 *R*	−112.5
4930	+ 68.4		

*Radial velocity corrected for solar motion.
R Listed in Roman's *Catalogue of High-Velocity Stars*.

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A CATALOGUE OF DWARF GALAXIES

BY

SIDNEY VAN DEN BERGH

1959
TORONTO, CANADA

A CATALOGUE OF DWARF GALAXIES

By Sidney van den Bergh

Abstract

A catalogue of dwarf galaxies north of $\delta = -23°$ has been compiled from the Palomar Sky Survey prints. The data indicate that the distribution of dwarf galaxies over the sky is non-uniform. A strong concentration of dwarf irregular galaxies is found in the vicinity of M 94 in Canes Venatici.

Introduction

Of the 22 known probable members of the local group of galaxies, 17 are low luminosity dwarfs. Holmberg (1950) has shown that dwarf galaxies also occur in the M81 and M101 groups. More recently Reaves (1956) has discussed the numerous dwarf galaxies which occur in the Virgo Cluster.

Dwarf Criteria

Inspection of the Palomar Sky Survey prints of clusters of galaxies shows that a class of faint objects can be isolated by the following criteria:

A, Low surface brightness.

B, Little or no central concentration of light on the red prints.

In view of the fact, that these objects are found to be more frequent in clusters than in the general field, it is reasonable to assume that they are dwarf galaxies. This conclusion is supported by the similarity which many of these objects have to dwarf galaxies in the local group. Almost all objects which satisfy criteria *A* and *B* are probable dwarf galaxies. However, many galaxies which are known or probable dwarfs do not satisfy *both* criteria.

Types of Dwarf Galaxies

The following types of dwarf galaxies may be distinguished:

Dwarf Irregulars (*DIr*)

Almost all dwarf irregular galaxies were found to be similar to one of the following prototypes in the local group, NGC 6822, IC 1613 and the Wolf-Lundmark system.

Dwarf Spirals (*DSp*)

Two distinct types of dwarf spirals exist. The most easily recognizable type consists of a short bright bar superimposed on a background of low surface brightness. This type is probably a dwarf edition of the normal barred spiral, from which it can be distinguished by the fact that no spiral arms emanate from the tips of the bar.

The second type of dwarf spiral is similar to the IC 1613 type of irregular galaxy. However the resolved images of stars and nebulosity are not distributed at random but lie in elongated patches resembling segments of a spiral arm.

No dwarf spirals are known in the local group.

Dwarf Ellipticals (*DEl*)

The surface brightness and central concentration criteria have not proved to be successful in distinguishing between giant and dwarf ellipticals on the Palomar *prints*. As a result the catalogue contains very few dwarf ellipticals.

Dwarf Spheroidal Galaxies (*DSph*)

The Draco System is the prototype of this kind of galaxy. These objects, which have a very low surface brightness, are rather easy to identify at large distances. Their identification becomes more difficult when they are relatively near by and completely resolved into stars. In this case their appearance on the Sky Survey prints is quite similar to that of a distant cluster of galaxies.

IC 3475 in the Virgo Cluster is the brightest known member of this class.

The Catalogue

The catalogue was compiled from the Palomar Sky Survey prints. It contains all dwarf galaxies with diameters larger than one minute of arc north of $\delta = -23°00'$, which satisfy criteria A and B. It is hoped that the catalogue will prove useful as a finding list for future investigations. Only a few of the galaxies in the catalogue are contained in the NGC, the IC and Holmberg's list of dwarf galaxies. Twelve of the dwarf galaxies in the catalogue are known members or possible members of the local group.

The first three columns of Table I are self-explanatory. The fourth column (ϕ) contains the maximum diameter of the galaxy on the blue print in millimetres (1 mm. = 67 sec. of arc). The fifth column gives the classification type of the galaxy. The sixth column gives the surface brightness (S) on the blue print on a scale ($--$, very low) to ($++$, relatively high). The seventh and eighth columns give the degree of resolution on the red (R) and blue (B) prints respectively on the following scale: $-$, unresolved; $\pm$, incipient resolution; $+$, clearly resolved; and $++$, resolved stars only.

The ninth column (C) gives an estimate of the colour of the object on a scale (0.0, very blue) to (1.0, very red). For $C = 0.6$ the brightness on the red and blue prints is equal. An N in the last column refers to a note at the end of the table.

The Colours of Dwarf Spirals

The individual colours, estimated on the scale $C = 0.0$ (very blue) to $C = 1.0$ (very red), are quite uncertain. However the mean colours for different types of galaxies are probably significant and are tabulated here. In deriving the mean colours dwarf galaxies near the galactic equator were excluded.

MEAN COLOURS OF DWARF GALAXIES

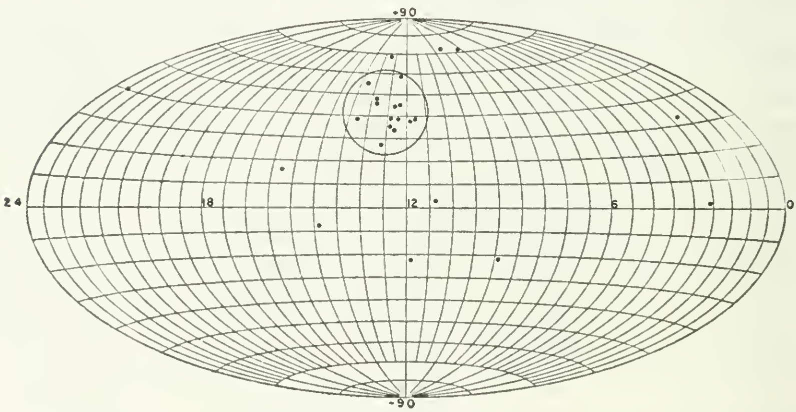
Type	C	n_{obs}
DIr	0.24	100
DSp	0.30	49
DSph	0.50	12
DEl	0.48	5

The Distribution of Dwarf Galaxies

The dwarf galaxies of Table I occur almost exclusively outside the 'zone of avoidance' at low galactic latitude. However even at high galactic latitude their distribution is distinctly non-random. In general the distribution of dwarf galaxies over the sky is similar to that of the brightest giant galaxies. However some small clusters of dwarf galaxies occur which are not associated with giant galaxies. The distribution of dwarf irregular galaxies, with diameters larger than two minutes of arc is shown in the figure. The mean distance of these dwarfs is probably smaller than that of the dwarf galaxies with a diameter less than two minutes of arc. More than half of these objects (excluding members of the local group) are located within 20° of M 94 (NGC 4736). This region also contains a large number of smaller dwarf irregular galaxies and dwarf spirals. In this connection it is of interest to note that the M 94 region is particularly rich in late type giant spirals and giant irregular galaxies.

A somewhat less conspicuous concentration of dwarf galaxies, occurs in the vicinity of M 81. This group contains a mixed population of *DIr*, *DSp*, and *DSph* galaxies.

The very pronounced clustering of dwarf galaxies in the Virgo cluster (Reaves 1956) does not show up well in our data. The reason for this is that almost all the dwarfs in the distant Virgo Cluster have diameters smaller than one minute of arc.



The positions are shown of dwarf irregular galaxies with diameters larger than two minutes of arc. (Probable members of the local group are not shown.) The circle indicates the position of the M 94 group.

REFERENCES

Holmberg, E. 1950, *Lund Medd*, ser. II, no. 128.
Morgan, W. W. 1958, *Publ. A.S.P.*, vol. 70, p. 364.
Reaves, G. 1956, *A. J.*, vol. 61, p. 69.

Note added in proof: Most of the spiral and irregular galaxies listed in the catalogue are of luminosity classes IV–V and V on the D.D.O. system. However, a few objects of luminosity class IV are included.

Richmond Hill, Ontario
January 15, 1959

TABLE I

Catalogue of Dwarf Galaxies

No.	α(1855)	δ(1855)	ϕ	Type	Resolution S	Resolution R	Resolution B	C	Notes
1	0^{h} 11^{m}	−19°50′	1.0	DSp?	±	±	±	0.2	
2	12	+10 05	1.0	DSp	+	±	+	0.2	N
3	25	+47 40	6.0	DEl	+	−	−	0.8	N
4	26	+30 40	1.0	DSp	±	−	±	0.2	
5	39	−12 20	1.5	DIr	±	−	±	0.2	
6	43	−21 50	1.0	DIr/DSp	±	−	±	0.0	N
7	54	+06 50	1.0	DIr	+	−	±	0.0	
8	57	+01 20	15.0	DIr	+	+	+	0.2	N
9	1 02	+48 50	1.5	DIr	±	−	±	0.4	N
10	14	+11 40	1.5	DIr/D?Sp	+	−	±	0.2	
11	22	+25 05	1.5	DSp	+	−	+	0.2	N
12	27	+03 40	1.5	D	±	−	−	0.2	
13	32	+15 10	1.5	DSph/DIr	−	−	−	0.2	N
14	41	−13 10	1.5	DSp	±	±	+	0.0	
15	42	−13 30	1.0	DEl	−	−	−	0.6	
16	44	+17 25	1.5	DSp	±	−	−	0.2	N
17	55	+21 15	1.5	DSp	±	−	+	0.0	
18	2 03	+06 05	1.0	D?	±	−	?	0.4	
19	16	+35 20	1.5	DIr	±	−	±	0.6	
20	19	−10 30	2.0	D?Sp	+	±	+	0.4	N
21	19	−22 05	1.5	DIr/DSph	±	−	−	0.4	N
22	24	+38 00	1.0	DIr	±	−	−	0.2	N
23	24	−11 25	1.0	DSp	±	−	±	0.4	N
24	25	+39 50	1.5	DIr/DSp	±	−	±	0.8	N
25	25	+32 50	2.0	DIr	±	±	+	0.2	N
26	26	+29 05	1.0	DIr	+	−	−	0.0	
27	33	+00 40	1.0	DIr	−	−	−	0.0	N
28	40	+03 15	3.0	DIr?	−	−	−	0.6	
29	42	+01 30	3.0	DIr	−	−	±	0.4	N
30	44	−01 45	1.5	DSp	±	−	±	0.2	N
31	3 07	−03 20	1.5	DIr/DSp	+	+	+	0.2	N
32	07	−05 20	1.0	DIr/DSp	±	±	+	0.4	
33	4 29	+74 40	1.0	DSp	±	−	±	0.4	
34	41	00 00	1.0	D?Ir	±	−	−	0.4	N
35	55	+16 10	1.0	DIr	±	±	±	0.8	N
36	5 01	−16 30	1.0	D?Sp	±	−	±	0.4	
37	13	−21 45	1.5	DIr?	−	±	±	0.6	N
38	16	+73 35	1.0	DIr	−	−	±	0.2	
39	36	+75 15	2.0	DSph	−	−	−	0.4	
40	6 53	+56 40	1.0	DIr	+	−	±	0.4	N
41	58	+53 40	1.0	DIr	±	−	±	0.4	
42	7 13	+69 30	5.0	D?Ir?	+	+	+	0.2	N
43	18	+41 05	1.0	DIr	+	−	±	0.2	
44	20	+67 10	1.5	DSph	−−	−	−	0.4	N
45	28	+03 05	2.0	DIr?	±	−	−	1.0	N
46	31	+40 25	1.0	DSph?	±	−	−	0.4	
47	34	+17 05	3.0	DIr?	±	−	−	0.4	N
48	47	+58 25	1.5	DSp?	±	−	−	0.2	
49	8 01	+46 55	1.0	DSp	±	−	−	0.2	
50	04	+71 10	6.5	DIr	+	+	+	0.2	N
51	08	+74 55	1.0	DSp	±	±	±	0.4	N
52	19	+42 20	1.0	DEl	±	−	−	0.4	
53	21	+66 40	1.0	DIr	±	±	+	0.2	

TABLE I

CATALOGUE OF DWARF GALAXIES (*cont.*)

No.	α(1855)		δ(1855)	φ	Type	Resolution S	R	B	C	Notes
54	9ʰ	00ᵐ	+06°30′	1.5	DIr/DSph	+	−	−	0.6	
55		03	+36 05	1.0	DIr	±	−	±	0.2	
56		03	−22 25	1.0	DSph?	−	−	−	0.8	
57		04	−14 25	1.0	DIr	±	−	±	0.2	N
58		05	+20 00	1.0	DIr	±	−	+	0.4	
59		06	+39 50	1.0	DSp	±	±	±	0.4	
60		13	−11 35	1.0	DIr	±	±	+	0.4	
61		14	−12 00	1.0	DIr	±	−	−	0.6	
62		15	−21 50	2.0	DIr	±	−	−	0.4	N
63		28	+71 50	2.5	DIr	−	±	±	0.2	N
64		42	+32 10	1.5	DIr	+	−	±	0.2	
65		44	+02 05	1.0	DIr	−	−	±	0.2	N
66		46	+69 45	1.5	DIr	±	−	±	0.2	N
67		48	+81 00	1.5	DSp	+	±	+	0.4	N
68		48	+29 30	2.0	DSp	±	−	−	0.0	N
69		51	+31 25	3.5	DIr	±	+	+	0.0	N
70		52	+06 00	3.0	DIr	+	±	+	0.2	N
71		55	+67 15	1.0	DSph	−−	−	−	0.6	
72	10	00	+30 15	1.0	DEl	±	−	−	0.4	
73		01	+30 50	1.0	DIr	±	−	±	0.2	
74		01	+13 00	8.5	DEl	+	+	+	0.4	N
75		04	−04 00	4.0	DIr	±	+	+	0.0	N
76		04	−13 05	1.5	DIr	±	−	±	0.2	
77		13	+71 40	2.0	DSp	+	±	+	0.6	
78		16	+68 20	1.0	DSph	−−	−	−	0.6	
79		17	+15 30	1.0	DSp	+	−	±	0.4	
80		19	+70 45	2.0	DSp	±	±	+	0.4	
81		19	+69 10	11.5	D?Ir?	+	+	+	0.2	N
82		20	+71 20	1.5	DIr?	±	±	±	0.6	
83		28	+32 15	1.0	DIr	+	−	±	0.2	
84		34	+35 15	4.0	D?Sp	±	±	+	0.4	N
85		34	−22 40	1.0	DIr	±	−	−	0.4	
86		35	+61 05	1.5	DIr	±	−	±	0.2	
87		40	+66 15	1.0	DSph	−−	−	−	0.4	
88		40	+14 50	1.0	DIr	+	−	±	0.4	N
89		43	+20 25	1.0	DIr	+	−	±	0.2	N
90		45	+08 25	1.0	DIr	−	−	±	0.4	
91		58	+20 35	1.0	DIr	±	−	−	0.4	
92	11	05	+54 20	1.0	DIr/DSp	+	−	±	0.2	
93		06	+22 55	5.0	DSph	−−	++	±	0.4	N
94		13	+03 20	2.0	DIr	+	±	+	0.2	
95		17	+04 10	1.5	D?Sp	++	+	+	0.2	N
96		36	+59 55	1.0	DSp	±	−	±	0.6	
97		42	+24 40	1.0	DIr	±	−	−	0.4	
98		43	+57 15	1.0	DSp	+	±	+	0.4	
99		44	+39 25	3.5	DIr	+	−	±	0.2	
100		45	+52 55	1.0	DSp	±	−	−	0.2	N
101		48	+32 20	1.0	DIr	±	−	−	0.4	
102		50	+51 40	1.0	DSp	−	−	−	0.4	N
103		51	−13 45	1.0	DSp	+	+	+	0.2	
104		51	−13 55	1.0	DIr	±	−	±	0.4	
105		51	+38 50	2.5	DIr	−	−	±	0.2	
106		51	−21 40	2.0	DIr	−	−	−	0.6	

TABLE I

CATALOGUE OF DWARF GALAXIES (*cont.*)

No.	α(1855)	δ(1855)	φ	Type	S	Resolution R	B	C	Notes
107	11ʰ 52ᵐ	+38°40′	1.5	DSp	+	±	±	0.4	N
108	57	−00 44	1.0	DIr	±	−	±	0.2	
109	12 00	+40 35	1.0	DIr	−−	−	−	0.2	N
110	04	+02 50	1.0	DSph	−	−	−	0.4	
111	04	+51 05	1.0	DIr	−	−	−	0.4	N
112	04	+18 50	1.0	DIr?	++	−	±	0.2	N
113	07	+37 00	1.0	DSph	−−	−	−	0.4	N
114	07	+13 35	1.0	DSp	±	−	±	0.2	
115	08	+14 20	1.0	DIr	±	−	−	0.2	
116	09	−10 40	1.5	DIr	±	±	±	0.4	N
117	10	+29 35	1.0	DIr	±	−	±	0.2	
118	10	−10 50	1.0	DIr	−	±	±	0.4	
119	13	+47 10	1.5	DSp	+	±	+	0.4	N
120	14	+46 40	1.0	DIr	±	±	+	0.0	
121	15	+01 15	1.0	DIr	±	−	+	0.0	
122	19	+71 10	1.5	DSp/DIr	+	−	±	0.4	
123	19	+59 05	2.0	DIr	±	−	+	0.0	
124	20	+13 55	1.0	DSp	+	−	−	0.0	
125	20	+44 15	3.0	DIr	+	±	±	0.0	N
126	20	+38 00	2.0	DIr	+	−	±	0.0	N
127	21	+38 00	1.0	DIr?	±	−	−	0.2	N
128	22	+03 35	1.5	DIr	±	−	±	0.2	
129	22	+44 00	2.0	DIr	±	±	+	0.0	N
130	22	+12 15	1.0	DIr	−	−	−	0.4	N
131	24	+30 30	1.0	DIr	±	−	±	0.2	
132	25	+13 35	1.0	DSph	±	−	−	0.6	N
133	26	+32 25	3.0	DIr	±	−	±	0.2	
134	26	−01 50	1.0	DIr	±	−	±	0.2	
135	27	+16 00	1.5	DSp	+	±	+	0.4	N
136	28	+16 00	1.0	DIr	±	−	±	0.4	N
137	28	+07 05	1.0	DSph	±	−	−	0.4	
138	29	+07 25	1.0	DIr	±	−	+	0.4	N
139	30	+07 55	1.0	DIr	±	−	+	0.4	
140	32	+08 45	1.0	DSp	++	+	+	0.2	N
141	35	+39 15	2.0	DIr	+	−	±	0.2	N
142	37	−04 55	2.0	DSp	±	±	±	0.6	
143	37	+35 10	2.0	DIr	−	−	±	0.2	
144	37	+01 15	1.0	DSp	+	±	±	0.4	
145	38	+12 50	1.0	DEl	±	−	−	0.6	N
146	38	−05 20	2.5	DIr/DSp	±	−	±	0.4	
147	40	+37 15	1.0	DIr?	−	−	−	0.2	
148	41	−04 30	1.5	DSph	−	−	−	0.6	
149	42	−03 15	1.0	DIr/DSp	+	−	±	0.2	
150	42	+51 55	1.5	DIr	±	±	+	0.4	N
151	43	−10 05	3.5	D?Sp	±	±	+	0.4	
152	45	−05 30	1.0	DIr	±	−	±	0.2	
153	46	−11 20	1.5	DIr	±	−	±	0.2	
154	47	+27 55	3.0	DIr	+	−	+	0.0	
155	49	+15 00	1.0	DIr	+	+	+	0.0	
156	50	+03 30	1.0	DIr	±	±	±	0.4	
157	51	+15 40	1.0	DEl?	±	−	−	0.4	
158	51	+03 35	1.0	DSp	±	±	±	0.6	
159	53	−14 55	1.5	DSph	−−	−	−	0.8	

TABLE I

Catalogue of Dwarf Galaxies (*cont.*)

No.	α(1855)		δ(1855)	φ	Type	Resolution S	Resolution R	Resolution B	C	Notes
160	12ʰ	54ᵐ	−03°55′	1.0	DSp	+	±	±	0.0	
161		55	−16 40	6.5	D?	±	+	+	0.4	N
162		58	−07 25	1.0	DSp	+	±	+	0.4	N
163		58	−07 10	1.0	DSp	±	−	±	0.4	N
164		59	−16 45	1.0	DIr?	−	−	±	0.4	
165	13	01	+68 30	2.5	DIr	+	−	±	0.2	
166		06	+37 05	1.5	DIr	+	−	+	0.2	N
167		07	+47 05	1.0	DIr	±	±	+	0.2	
168		08	+46 40	3.0	DIr	+	+	+	0.0	
169		09	+48 15	3.0	DIr	±	±	±	0.0	
170		09	+26 10	1.0	DIr?	+	−	−	0.2	N
171		11	−07 40	1.0	DIr	+	−	+	0.2	
172		12	+42 45	1.5	DSp	+	−	±	0.6	N
173		14	+10 30	1.5	D?Sp	+	−	±	0.2	
174		19	−21 30	1.0	DIr	±	±	±	0.2	
175		20	+58 35	1.5	DIr	±	−	±	0.4	N
176		24	+46 05	1.5	DSp	+	−	±	0.2	
177		30	+46 55	1.0	DSp	±	−	+	0.4	
178		30	+46 40	1.0	DSp	±	−	±	0.4	
179		30	+08 25	2.0	D?Ir	+	−	±	0.4	
180		31	−09 05	1.0	D?Sp	+	±	+	0.4	
181		34	+41 25	1.5	DIr	+	−	±	0.4	
182		36	+40 20	1.0	DIr	±	−	−	0.2	
183		45	+38 45	2.0	DIr	+	−	−	0.2	N
184		48	+18 30	2.0	DSp?	±	−	−	0.2	N
185		49	+54 35	2.5	DIr	+	−	+	0.0	N
186	14	00	+55 10	1.0	DIr	+	±	+	0.0	N
187		09	+23 40	1.0	DIr	+	−	±	0.0	
188		09	+17 15	1.0	DSp	±	−	±	0.4	
189		17	+46 05	1.0	DIr	±	−	±	0.2	
190		19	+45 10	1.0	DIr	+	−	±	0.2	
191		20	+56 55	1.5	DSp	±	±	±	0.6	
192		24	+45 05	1.0	DSp	±	−	±	0.2	
193		30	+59 10	1.0	DSp	+	±	+	0.2	
194		31	+57 50	1.0	DIr	±	−	−	0.4	
195		31	−08 00	2.0	DIr	−	−	±	0.0	
196		38	+08 30	1.0	DIr	−	−	−	0.4	
197		42	−09 30	2.0	D?Sp	+	±	+	0.2	N
198		57	+53 15	1.0	DIr	+	±	±	0.2	
199	15	07	+67 50	20.0	DSph	−−	++	++	?	N
200		32	+44 40	1.0	DSp	±	±	±	0.2	
201		35	+00 55	1.0	DIr?	+	−	±	0.4	N
202		45	+16 45	2.0	DIr	−	−	±	0.0	
203		55	+82 15	1.0	DSp	+	−	±	0.4	
204	16	12	+47 25	1.5	DSp	+	±	+	0.2	
205		16	+64 15	1.0	DSp	±	−	±	0.2	N
206		51	+53 20	1.0	DSp	−	±	±	0.2	N
207	17	13	+14 35	1.0	DSp	±	−	−	0.2	
208		18	+58 05	8.0	DSph	−−	++	++	?	N
209	19	37	−15 10	12.5	DIr	+	+	+	0.2	N
210	20	39	−13 25	1.5	DEl/DIr	−−	−	±	0.0	N
211	22	02	−19 35	1.0	DEl?	±	−	−	0.8	
212		09	−21 55	1.5	DSp	++	+	+	0.0	

TABLE I

Catalogue of Dwarf Galaxies (*concluded*)

No.	α(1855)		δ(1855)	φ	Type	Resolution S	R	B	C	Notes
213	22h	27m	+32°05′	1.5	DIr	±	−	±	0.2	N
214		29	−03 40	2.0	D?Ir	+	±	+	0.0	
215		32	−05 30	1.0	DIr	−	−	±	0.0	
216	23	21	+13 55	4.0	DIr/DEl	±	±	±	0.4	N
217		23	+40 10	2.5	DIr	±	−	±	0.2	N
218		28	+17 25	1.0	DIr/DSp	+	±	±	0.4	N
219		30	−00 30	1.5	D?Ir	+	−	±	0.4	N
220		42	+25 25	1.0	DIr	+	−	±	0.2	
221		54	−16 15	11.0	DIr	+	+	+	0.2	N
222		56	+14 30	1.5	DIr	±	−	±	0.2	

Notes

2. Has two very faint companions.
3. NGC 147; member of local group.
6. Member of NGC 247, NGC 253 group.
8. IC 1613; member of local group.
9. Obscured.
11. Good example of dwarf barred spiral.
13. Near M 74.
16. Largest of a small cluster of dwarfs.
20. In NGC 945 group.
21. Near NGC 908.
22. Elongated.
23. In NGC 945 group.
24. Obscured.
25. Near NGC 925.
27. In a cluster.
29. In a cluster.
30. In a cluster.
31. Near NGC 1253.
34. Obscured.
35. Obscured.
37. Star projected on nucleus.
40. Has *DSp* companion.
42. NGC 2366.
44. Near NGC 2403.
45. Obscured. Emission nebula?
47. Galactic nebula?
50. Ho II.
51. Has dwarf companion.
57. Near NGC 2781.
62. Near NGC 2835. Very elongated.
63. Ho I.
65. Near NGC 3044.
66. Near M 81; M 81 also has another dwarf companion.
67. NGC 3057.
68. Companion to Leo A?
69. Leo A = Leo III; possible member of local group.
70. Sextans B; possible member of local group.
74. Regulus system = Leo I; probable member of local group.

75. Sextans A; possible member of local group.
81. IC 2574.
84. May be low density spiral like NGC 4236.
88. In a cluster.
89. Elongated.
93. Leo B = Leo II; probable member of local group.
95. NGC 3664. Reproduction of this dwarf (?) barred spiral in Morgan (1958).
100. Near NGC 3953.
102. Near NGC 4026.
107. NGC 4025.
109. Near NGC 4145.
111. Near NGC 4157.
112. Elongated.
113. Near NGC 4214.
116. Very elongated.
119. NGC 4288.
125. Near NGC 4449.
126. Blue nucleus.
127. Blue nucleus.
129. Near NGC 4449.
130. IC 3418?
132. IC 3475.
135. NGC 4523.
136. IC 3522.
138. IC 3576.
140. IC 3617.
141. IC 3687.
145. IC 3720.
150. NGC 4707. Star projected on nucleus.
161. Very elongated, multiple nuclei. Has three dwarf companions.
162. Near NGC 4958.
163. Near NGC 4958.
166. Ho VIII; near NGC 5033.
170. Elongated.
172. Near M 63.
175. Near NGC 5204.
183. Elongated.
184. Nucleus very blue.
185. Ho IV.
186. NGC 5477; companion of M 101.
197. Colliding giant spirals?
199. Ursa Minor system; probable member of local group. This system was overlooked during the search for dwarf galaxies; it has however been included in the catalogue for the sake of completeness.
201. Very elongated.
205. Has dwarf companions.
206. Has distant *DIr* companion.
208. Draco system; member of local group.
209. NGC 6822; member of the local group. Obscured.
211. Has dwarf companion.
213. Blue nucleus.
216. Pegasus system; possible member of local group.
217. Obscured.
218. Brightest member of a small cluster of dwarf galaxies.
219. Near NGC 7716.
221. Wolf-Lundmark system; possible member of local group.

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A RECLASSIFICATION OF THE NORTHERN SHAPLEY-AMES GALAXIES

SIDNEY VAN DEN BERGH

1960
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A RECLASSIFICATION OF THE NORTHERN SHAPLEY-AMES GALAXIES

Introduction

The Shapley-Ames catalogue of galaxies brighter than the thirteenth magnitude, which was published almost thirty years ago, is still the only complete survey of bright extra-galactic nebulae, which covers the entire sky. The nebular types given in the Shapley-Ames (1932) catalogue were derived from thirteen different sources and are both inhomogeneous and incomplete. The recent publication of the Palomar Sky Survey has made it possible to reclassify all the northern Shapley-Ames galaxies on a homogeneous system. 935 of the 1,249 galaxies contained in the Shapley-Ames catalogue are located in the region north of $\delta = -27°$, which is covered by the Palomar Sky Survey.

The Catalogue

The first three columns contain the name of each galaxy and its 1950 co-ordinates, taken from the Shapley-Ames catalogue. For convenience the entries have been arranged in order of increasing NGC or IC number, rather than by right ascension for 1950.

The fourth column contains the DDO type and luminosity class. The classification system for galaxies of types Sb, Sc, Ir, SD and N has been described elsewhere (van den Bergh 1960a, 1960b).

A short description of types E, Sa and SBa is given below:

E—Unresolved galaxies with elliptical isophotes. Surface brightness decreases smoothly with increasing distance from the nucleus. E and S0 galaxies cannot be distinguished on the Sky Survey prints. Highly flattened objects of type S0 have therefore been denoted by the symbols E8 and E9.

Sa—Unresolved galaxies with more or less elliptical isophotes. Surface brightness decreases more abruptly at edge of disk than in type E.

SBa—Smooth unresolved main body and bar. In some cases surrounded by unresolved halo or ring segments.

The spectral types in column 5 were taken from Humason *et al.* (1956). The Yerkes concentration class Y in column 6 was taken from Morgan (1958). The integrated colours C_0 in column 7 were taken from Holmberg (1958) and corrected for galactic absorption by the equation

$$C_0 = C - 0.06 \operatorname{cosec} |b^I| \tag{1}$$

The diameters in column 8 were measured on the blue prints of the Palomar Sky Survey. For galaxies of types Sa, Sb, Sc and Ir the diameters are maximum diameters. On the whole these diameters agree rather well with those given in the Shapley-Ames catalogue. From those galaxies with diameters $\varphi \geqslant 1.0$ minutes of arc one obtains

Sb I, I–II, II $\qquad \bar{\varphi}_{SA} = 1.00\, \bar{\varphi}_{DDO}$ (2)

Sc I, I–II, II $\qquad \bar{\varphi}_{SA} = 0.98\, \bar{\varphi}_{DDO}$ (3)

Sc II–III, III, III–IV $\qquad \bar{\varphi}_{SA} = 1.07\, \bar{\varphi}_{DDO}$ (4)

S IV, IV–V, V $\qquad \bar{\varphi}_{SA} = 1.06\, \bar{\varphi}_{DDO}$ (5)

The smooth radial decrease of the surface brightness in elliptical galaxies makes it impossible to determine maximum diameters with confidence. The diameters which are given in the catalogue might be described as "diameters of maximum contrast" on the Sky Survey prints. It should be emphasized that these diameters are quite uncertain. For elliptical galaxies the relation between the Shapley-Ames and DDO diameters is given by

E $\qquad \bar{\varphi}_{SA} = 1.36\, \bar{\varphi}_{DDO}$ (6)

The apparent integrated magnitudes of galaxies were taken from the following sources and are listed in order of preference:

1. Holmberg (1958).
2. Stebbins and Whitford (1952).
3. Humason *et al.* (1956).
4. Pettit (1954).
5. Shapley and Ames (1932).

The Pettit and the Stebbins and Whitford magnitudes were not used in those cases in which the maximum diameter of the galaxy greatly exceeded the size of the diaphragm used in their photoelectric observations. Only magnitudes by Holmberg are given in two decimals.

Column 10 gives the distance moduli of those galaxies to which luminosity classes could be assigned. The magnitude calibration was taken from Table I. The apparent distance moduli were corrected for galactic absorption by the equation

$$(m-M)_0 = (m-M) - 0.24 \text{ cosec } |b^I| \tag{7}$$

Those distance moduli in column 11 which are given to one decimal were derived from the observed radial velocities of individual field

TABLE I

MAGNITUDE CALIBRATION OF LUMINOSITY CLASSES

Type and Class	$\bar{M}_{pg}$	Type and Class	$\bar{M}_{pg}$
Sb I	−20.4	Sc I	−20.0
Sb I–II	−19.9	Sc I–II	−19.7
Sb II	−19.4	Sc and Ir II	−19.4
Sb II–III	−18.6	Sc and Ir II–III	−18.9
Sb III	−18.0	Sc and Ir III	−18.3
		Sc and Ir III–IV	−18.0:
		S and Ir IV	−17.3:
		S and Ir IV–V	−16.1:

galaxies. Those given to two decimals were obtained from the mean redshifts of cluster members. A Hubble constant of 100 km./sec./mpc. was assumed.

The number of individual distance moduli obtained by different methods are given below:

From DDO luminosity classifications 411
From radial velocities of field nebulae 365
From cluster moduli 244

An asterisk in the last column refers to a note at the end of the table.

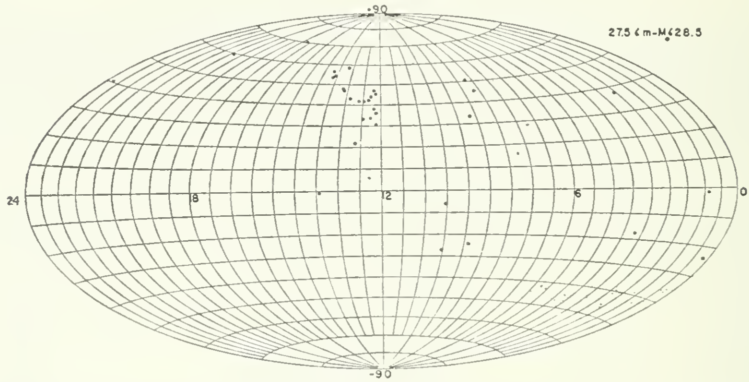
THE SPACE DISTRIBUTION OF GALAXIES

The catalogue contains distance moduli for 82 per cent. of the northern Shapley-Ames galaxies. The data are therefore sufficiently complete to investigate the spatial distribution of the nearer galaxies:

$$26.5 \leqslant m-M_0 \leqslant 27.5$$

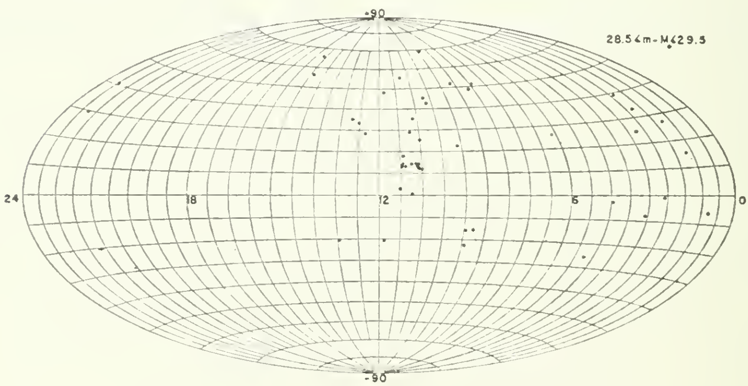
Eight of the ten Shapley-Ames galaxies within this distance interval are members of the M81 group.

$27.5 \leqslant m-M_0 \leqslant 28.5$ (Figure 1)



Most of the galaxies in this distance interval are members of the Canes Venatici cluster. No other clusters are apparent in the figure.

$28.5 \leqslant m-M_0 \leqslant 29.5$ (Figure 2)



Only two small clusters show on the figure. They are the M96 group ($\alpha \simeq 10^h40^m$, $\delta \simeq +13°$) with $\bar{V}_c = +676$ km./sec. and the M66 group ($\alpha \simeq 11^h10^m$, $\delta \simeq +14°$) with $\bar{V}_c = +598$ km./sec. The small difference in radial velocity and the small angular separation of these two groups suggests that they are physically associated.

(*Continued on page 196*)

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
16	$0^h06^m.5$	+27°27'	E3	G5	k	- --	1'.0 x 0'.7	13.2	-- -	32.6	-
23	07.3	+25 39	S(t?)	F5	g	- --	- - - -	13.0	-- -	33.4	-
24	07.4	-25 15	Sb III	--	-	- --	5.0 x 0.7	12.2	30.0	-- -	-
45	11.4	-23 27	S⁻ IV-V	Em	-	- --	8.0 x 5.5	12.1:	28.0:	28.4:	-
95	19.6	+10 12	Sc*:	--	f	- --	1.1 x 0.9	13.1	-- -	-- -	-
128	26.7	+02 33	E8	G7	k	- --	2.2 x 0.4	12.7	-- -	33.2	-
147	30.4	+48 14	E4:p	--	-	0.59	4.5:x 2.5:	10.57	-- -	-- -	-
151	31.6	-09 58	Sb+ II:	--	-	- --	3.1 x 1.1	12.4	31.6:	-- -	-
157	32.3	-08 40	Sc(*) I	G4	af	0.65	2.8 x 2.1	11.17	30.9	31.4	-
175	34.9	-20 12	SBb I	--	-	- --	1.2 x 1.2	12.8	33.0	-- -	-
178	36.6	-14 27	Pec(t?)	--	-	- --	1.2 x 0.7	13.0	-- -	-- -	*
185	36.1	+48 04	E0:	G0	-	0.62	2.2:x 2.2:	10.29	-- -	-- -	-
205	37.6	+41 25	E6:(t?)	A8	-	0.54	10: x 4.5	8.89	-- -	-- -	-
210	38.0	-14 09	Sb⁻ I	--	-	- --	4.5 x 2.4	11.8	32.0	31.3	-
214	38.7	+25 14	Sb I	G3	g	- --	1.6 x 1.0	12.8	32.8	33.4	-
221	40.0	+40 36	E2	G3	k	0.74	3.4 x 2.8	9.06	-- -	-- -	-
224	40.0	+41 00	Sb I-II	G5	k	0.70	160: x35:	4.33	23.6	-- -	-
227	40.1	-01 48	E2 or Sa	G3	-	- --	0.8 x 0.6	13.5	-- -	33.7	-
237	40.9	-00 24	Sc II:	--	-	- --	1.2 x 0.8	13.2	32.3:	-- -	-
245	43.7	-01 59	Ir or Sc	--	-	- --	1.0 x 1.0	12.9	-- -	-- -	-
247	44.6	-21 01	S⁻ IV	Em	a	- --	18.2 x 4.5	9.47	26.5	-- -	-
253	45.1	-25 34	Sc(*)p or SD	Em	af:	- --	24.6 x 4.5	7.0:	-- -	-- -	-
255	45.2	-11 45	Sb+n II:	--	-	- --	3.3 x 2.5	12.4	31.6:	31.5	-
268	47.6	-05 28	Sc II	--	-	- --	1.1 x 0.9	13.2	32.3	-- -	-
274	48.5	-07 20	E1	--	-	- --	0.9 x 0.8	13.0	-- -	-- -	-
275	48.5	-07 20	St	--	-	- --	1.1 x 0.8	13.0	-- -	-- -	*
278	49.2	+47 18	E0(p?)	F0	f	- --	1.3 x 1.3	11.5	-- -	29.7	-
309	54.0	-10 13	Sc I-II	--	-	- --	2.4 x 2.1	12.5	32.0	-- -	-
337	57.3	-07 51	Scn II-III:	--	-	- --	- - - -	12.2	30.8:	-- -	-
357	$1^h00.8$	-06 37	SBa	G4	-	- --	1.6 x 1.1	13.0	-- -	32.1	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
404	$1^h06^m.6$	+35°27'	E0	F8	-	0.79	2'.1 x 2'.0	11.16	-- -	25.9:	-
428	10.4	+00 43	Scp III-IV	--	af:	0.24	3.9 x 3.6	11.74	29.5	30.3	-
450	13.0	-01 07	S IV-V	--	-	- --	2.6 x 2.0	12.6	28.4:	-- -	-
470	17.1	+03 09	Sc*	--	f	- --	1.7 x 1.1	12.4	-- -	-- -	-
473	17.5	+16 14	E4(p?)	--	g?	- --	1.0 x 0.6	13.1	-- -	-- -	-
474	17.5	+03 10	Et	G5	-	- --	- - - -	13.0	-- -	31.9	*
488	19.1	+05 00	Sb⁻ I	G7	k	0.78	4.2 x 3.3	11.10	31.2	31.8	-
514	21.3	+12 39	Sc I-II:	G0	af	- --	2.7 x 2.2	12.3	31.7:	32.1	-
520	22.0	+03 32	Pec	--	f?	0.74	- - - -	12.35	-- -	31.7	*
521	22.0	+01 28	S(B)b(n?)	--	k	- --	- - - -	13.0	-- -	-- -	-
524	22.1	+09 16	E1	G3	-	- --	1.8 x 1.7	11.6	-- -	32.1	-
533	22.9	+01 30	E2:	--	k	- --	0.9:x 0.7:	13.0	-- -	-- -	-
578	28.0	-22 56	Sc II	--	af	0.32	4.1 x 2.2	11.37	30.5	31.5	-
584	28.8	-07 07	E4	G5	k	- --	1.6 x 1.0	11.4	-- -	31.4	-
596	30.3	-07 17	E2	G3	-	- --	1.5 x 1.2	12.1	-- -	31.6	-
598	31.1	+30 24	Sc II-III	A7	f	0.28	65 x35	6.19	24.6	-- -	-
615	32.6	-07 35	Sb II-III	--	-	- --	2.5 x 1.0	12.6	30.9	-- -	-
628	34.0	+15 32	Sc I	F5	fg	0.32	10.6 x 9.0	9.74	29.4	29.2	-
636	36.6	-07 45	E1	G5	-	- --	0.9 x 0.8	12.4	-- -	31.5	-
670	44.5	+27 38	E4	--	-	- --	0.9 x 0.5	13.0	-- -	-- -	-
672	45.0	+27 11	SBc III	--	a	0.34	5.5 x 1.5	11.31	29.2	28.5:	-
681	46.7	-10 40	Sb⁻	G5	-	- --	1.6 x 0.8	12.8	-- -	31.2	-
701	48.6	-09 57	S(n*)	--	-	- --	2.2 x 0.8	12.7	-- -	-- -	-
718	50.7	+03 57	Sbn	--	gk	- --	1.2 x 1.0	12.5	-- -	31.4	-
720	50.6	-13 59	E3	G4	k	- --	1.6 x 1.1	11.3	-- -	31.3	-
741	53.8	+05 23	E1	G5	k	- --	0.9 x 0.8	13.0	-- -	33.8	-
750	54.6	+32 58	E	G7	g	- --	- - x 0.6	13.7	-- -	33.6	-
753	54.6	+35 41	Sc II:	--	f	0.35	1.9 x 1.6	12.91	31.7:	33.5	-
772	56.6	+18 46	Sbnt I	G4	f	0.58	- - - -	11.10	31.1	32.0	-
777	57.3	+31 12	E2	--	-	- --	0.9 x 0.7	13.0	-- -	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
779	$1^h57^m.2$	-06°12'	Sb^- II-III	--	g	- --	3'.7 x 0'.9	11.9	30.2	-- -	-
788	58.6	-07 03	Sa	G0:	-	- --	1.2 x 0.9	12.4	-- -	33.1	-
821	$2^h05.6$	+10 46	E2	G5	-	- --	1.2 x 0.9	12.0	-- -	31.4	-
864	12.8	+05 45	Sc II	--	-	- --	3.5 x 2.3	11.6	30.7	31.1	-
877	15.3	+14 19	Sc I:	--	af	- --	1.7 x 1.1	12.4	32.0:	33.1	-
890	19.1	+33 02	E4	G4	k:	- --	1.1 x 0.7	12.6	-- -	33.1	-
891	19.3	+42 07	Sb	G1	gk:	0.61	11.8 x 1.1	10.85	-- -	27.0:	-
895	19.1	-05 45	Sb^+ II	--	-	- --	2.8 x 2.2	12.2	31.3	-- -	-
908	20.8	-21 27	Sc I	--	af	0.48	5.0 x 2.3	10.74	30.5	31.1	-
922	22.9	-25 01	Scp II-III:	--	-	- --	1.2 x 1.2	12.4	31.0:	-- -	-
925	24.3	+33 22	S(B)c II-III	F0	af	0.25	9.5 x 4.3	10.53	28.8	29.1	-
936	25.1	-01 22	SBa	G3	k	0.81	3.3 x 2.5	11.21	-- -	30.7	-
941	26.0	-01 22	Sc III-IV	--	-	0.32	1.9 x 1.3	12.84	30.5	-- -	-
949	27.6	+36 56	SD?	--	-	- --	1.2 x 0.5	12.8	-- -	-- -	-
955	28.0	-01 19	E8	--	-	- --	2.0 x 0.5	13.1	-- -	-- -	-
958	28.1	-03 09	$S(B?)b^+$ I-II	--	-	- --	1.8 x 0.6	13.0	32.6	-- -	-
972	31.3	+29 06	Sc(n) II:	F3	a?	- --	2.5 x 0.9	12.1	31.0:	31.1	-
976	31.2	+20 44	Sbn II:	--	f	- --	1.1 x 1.0	12.7	31.7:	-- -	-
991	33.2	-07 22	S IV:	--	-	- --	1.8 x 1.8	12.7	29.7:	-- -	-
1022	36.1	-06 53	Sbn	--	-	- --	1.8 x 1.4	12.0	-- -	-- -	-
1023	37.2	+38 52	E7p	G5	-	0.78	4.0 x 1.2	10.48	-- -	29.3	-
1035	37.0	-08 20	Pec or Sc*	--	-	- --	1.9 x 0.6	12.8	-- -	-- -	-
1048	38.2	-08 45	Scn	--	-	- --	4.5 x 2.6	12.5	-- -	-- -	-
1052	38.6	-08 28	E2	G5	k	0.73	1.3 x 1.0	11.69	-- -	30.8	-
1055	39.2	+00 16	Sb II-III	--	-	0.70	6.7:x 1.5	11.38	29.7	-- -	-
1058	40.2	+37 08	Sc* III-IV:	--	af	0.36	- - - -	11.74	29.0:	26.7:	-
1068	40.1	-00 14	Sbp	F0:	g	0.64	6.0 x 5.0	9.63	-- -	30.2	-
1073	41.2	+01 10	S(B)c II	--	af	0.33	4.5 x 4.2	11.43	30.5	31.4	-
1084	43.5	-07 47	Sc I-II	F5	a	- --	2.1 x 1.1	11.1	30.5	30.9	-
1087	43.9	-00 42	Sc* III:	F0	a	0.35	2.2 x 1.2	11.45	29.4:	31.3	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
1090	$2^h44^m.0$	-00°27'	S^-n IV:	--	f	0.45	2'.8 x 1'.0	12.51	29.5:	-- -	-
1140	52.2	-10 14	Pec	F2:	-	- --	1.1 x 0.5	12.8	-- -	30.9	-
1156	56.7	+25 03	Ir^+ IV:	Em	a	0.25	- - - -	11.85	28.6:	28.5:	-
1169	$3^h00.1$	+46 12	S(B)b^- II?	--	fg	- --	2.2 x 1.9	13.0	-- -	-- -	-
1172	59.3	-15 02	E1	--	-	- --	0.8 x 0.7	13.1	-- -	-- -	-
1175	01.3	+42 08	Snn:	--	k	- --	1.1 x 0.2	13.0	-- -	-- -	-
1179	59.7	-19 06	Sp or N	--	-	- --	5.4 x 3.1	13.0	-- -	-- -	-
1187	00.4	-23 04	S(B?)c I	--	af	- --	5.5 x 3.7	11.3	31.0	30.8	-
1199	01.3	-15 48	E2	G2	-	- --	0.9 x 0.7	12.7	-- -	32.0	-
1201	02.0	-26 15	Sa	G5	-	- --	2.2 x 1.2	11.7	-- -	31.1	-
1209	03.8	-15 48	E5	G4	-	- --	1.1 x 0.5	12.6	-- -	32.0	-
1232	07.5	-20 46	Sc I	--	f	0.39	7.0 x 5.5	10.46	30.2	31.2	-
1241	08.8	-09 07	Sb^+t	--	-	- --	1.8 x 1.0	13.0	-- -	-- -	-
1255	11.4	-25 58	Sc II	--	-	- --	3.5 x 2.2	12.1	31.2	-- -	-
1270	15.6	+41 18	E2	G4	-	- --	0.6 x 0.5	12.7	-- -	33.5	-
1297	17.0	-19 16	E2	--	-	- --	1.0 x 0.8	13.0	-- -	-- -	-
1300	17.5	-19 35	SBb I	--	f	0.46	5.7 x 3.5	11.11	31.2	30.9	-
1302	17.7	-26 14	S(B)a	G3	k	- --	3.4 x 3.2	11.1	-- -	31.0	-
1309	19.8	-15 35	Sc II-III	--	f	- --	1.9 x 1.7	11.8	30.4	-- -	-
1325	22.3	-21 43	Sbn(*)	--	-	0.58	4.2 x 1.1	12.22	-- -	-- -	-
1332	24.1	-21 31	E7	G2	k	- --	3.4 x 1.0	11.0	-- -	30.9	-
1337	25.6	-08 34	S^- IV:	--	-	0.35	5.2 x 0.9	12.26	29.2:	-- -	-
1353	29.8	-21 00	Sb II-III	--	-	- --	2.5 x 0.9	12.4	30.7	-- -	-
1357	30.9	-13 50	S	--	-	- --	1.4 x 0.9	12.5	-- -	-- -	-
1358	31.2	-05 16	S(B)b^- II:	--	-	- --	2.0 x 1.2	13.1	32.2:	-- -	-
1359	31.5	-19 41	SB^+p IV	--	-	- --	1.6 x 1.3	12.5	29.5	31.4	-
1371	32.8	-25 06	S(B)a	--	-	- --	5.6 x 3.5	12.2	-- -	-- -	-
1376	34.7	-05 12	Sc II-III:	--	-	- --	1.4 x 1.3	12.9	31.4:	-- -	-
1385	35.2	-24 40	Sc I-II	--	af	- --	2.4 x 1.8	11.5	30.9	31.4	-
1395	36.3	-23 11	E3	G7	k	- --	2.1 x 1.4	11.4	-- -	31.1	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
1398	$3^h36^m.8$	-26°30'	S(B)b⁻ I	--	k	- --	6'.8 x 4'.5	10.4	30.5	30.7	-
1400	37.2	-18 51	E1	G4	-	- --	0.8 x 0.7	12.3	-- -	27.9:	-
1407	37.9	-18 44	E0	G3	-	- --	1.1 x 1.1	11.2	-- -	31.2	-
1415	38.7	-22 43	Sb⁺(t?) III	F8	-	- --	1.7 x 0.8	12.8	30.5	30.7	*
1417	39.5	-04 48	Sb I-II:	G0	-	- --	1.7 x 1.1	12.9	32.4:	33.0	-
1421	40.2	-13 40	Sb⁺ I:	--	-	- --	3.0 x 0.6	12.0	32.1:	-- -	-
1426	40.6	-22 16	E2	G4	-	- --	1.0 x 0.8	12.6	-- -	30.5	-
1439	42.6	-22 05	E1	G2	-	- --	1.0 x 0.9	12.9	-- -	31.4	-
1440	42.8	-18 27	S(B)a	--	-	- --	1.0 x 0.7	13.0	-- -	-- -	-
1452	43.1	-18 47	SBa	--	-	- --	1.7 x 0.9	13.0	-- -	-- -	-
1453	44.0	-04 08	E2	G0	-	- --	0.8 x 0.6	12.9	-- -	33.0	-
1461	46.1	-16 32	Sa	--	-	- --	1.9 x 0.5	12.8	-- -	-- -	-
1507	$4^h01.8$	-02 20	S	--	-	- --	3.2 x 0.5	12.9	-- -	-- -	-
1518	04.7	-21 18	Scp or S(B)cp	--	a	- --	2.4 x 0.9	12.3	-- -	29.7	-
1521	06.2	-21 11	E3	G5	-	- --	0.7 x 0.5	13.0	-- -	33.0	-
1569	26.0	+64 45	Irp III-IV?	Em	a	- --	2.1 x 0.8	11.75	-- -	25.4:	-
1600	29.2	-05 10	E2	G7	-	- --	0.8 x 0.6	12.2	-- -	33.4	-
1625	34.6	-03 24	S(n)	--	-	- --	1.8 x 0.3	13.1	-- -	-- -	-
1637	38.9	-02 56	Scn	F8	f	0.38	2.6 x 1.9	11.26	-- -	28.6:	-
1638	39.1	-01 53	E2	--	-	- --	0.6 x 0.5	13.1	-- -	-- -	-
1640	40.1	-20 32	SBb⁻ II	--	-	- --	2.0 x 1.1	12.4	31.4	30.9	-
1659	44.0	-04 53	Sc* III	--	-	- --	1.1 x 0.9	13.2	31.0	-- -	-
1667	46.2	-06 24	Sb⁺ II:	--	-	- --	1.0 x 0.8	12.9	31.8:	-- -	-
1700	54.4	-04 56	E1t	G4	-	- --	0.9 x 0.8	12.1	-- -	32.9	-
1726	57.3	-07 49	E2	--	-	- --	0.6 x 0.5	13.0	-- -	-- -	-
1744	57.9	-26 06	S(B)c III:	--	-	- --	7.6 x 3.1	12.1	30.0:	28.4:	-
1784	$5^h03.2$	-11 56	S(B)c II:	--	-	0.44	4.5 x 2.3	12.39	31.3:	-- -	-
1832	10.0	-15 47	Sc II	G4	-	- --	2.2 x 1.1	12.0	30.9	31.4	-
1961	36.8	+69 24	Sbntp I(?)	--	f	0.45	3.7 x 1.6	11.68	-- -	33.0	-
1964	31.2	-21 59	Sb II	--	-	0.54	5.4 x 1.1	11.61	30.4	31.1	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
2139	$5^h58^m.6$	-23°49'	Scp	--	-	- --	1'.6 x 1'.3	11.9	-- -	31.1	-
2146	$6^h10.7$	+78 23	Snnt	F0:	-	0.44	5.1 x 2.8	11.26	-- -	29.9	-
2149	01.1	-09 44	--	--	-	- --	- - - -	-- -	-- -	-- -	*
2179	05.9	-21 44	Sa	--	-	- --	0.9 x 0.7	13.0	-- -	-- -	-
2196	10.1	-21 47	Sb I-II:	--	-	- --	1.7 x 1.3	12.6	31.7:	-- -	-
2207p	14.3	-21 21	Sct I:	G1	-	- --	2.8 x 1.9	11.4	30.6:	32.0	*
2207f	14.3	-21 21	St	--	-	- --	2.1 x 0.9	-- -	-- -	-- -	*
2217	18.7	-27 14	SBa	G2	-	- --	3.1 x - -	11.8	-- -	30.6	-
2223	22.5	-22 49	S(B)b⁻ II: or N	--	-	- --	- - - -	12.7	-- -	-- -	-
2268	$7^h01.3$	+84 30	Sbn:	--	f	0.48	2.3 x 1.5	12.18	-- -	32.0	-
2276	11.0	+85 52	Sc* I:	--	af	0.24	2.2 x 1.9	11.91	31.4:	32.1	-
2300	16.5	+85 50	E1	G5	k	0.90	1.0 x 0.9	12.25	-- -	31.7	-
2314	03.8	+75 19	E1 p?	G5	k	- --	0.7 x 0.6	13.3	-- -	33.0	-
2336	16.2	+80 20	Sb I or Sc I	--	f	0.39	5.7 x 2.8	11.03	30.7	31.9	-
2339	05.4	+18 52	Sc II-III	G0	af	- --	2.1 x 1.3	12.5	30.4	31.8	-
2347	11.6	+64 54	Sbn:	--	-	- --	1.0 x 0.8	13.1	-- -	33.3	-
2366	23.6	+69 08	S⁺ IV-V or Ir⁺ IV-V	--	a	0.22	4.5:x 2.0:	11.41	27.0:	26.53	-
2403	32.0	+65 43	Sc III	F2	a	0.20	16.8:x10.0:	8.80	26.6	26.53	-
2441	47.1	+73 06	Sc II:	--	af	- --	1.2 x 1.0	13.0	32.0:	32.9	-
2460	52.7	+60 31	Sb⁺t III:	G2	g	- --	- - - -	12.7	30.2:	30.9	-
2500	58.2	+50 54	S⁺ IV	--	a	0.35	2.5 x 1.9	12.13	29.0	28.5:	-
2523	$8^h09.2$	+73 45	SBb⁻ I	--	fg	- --	2.3 x 1.1	12.6	32.6	32.8	-
2525	03.3	-11 17	S(B)cp II?	--	-	- --	2.4 x 1.3	12.30	-- -	31.3	-
2537	09.7	+46 09	SD:	Em	a	- --	1.1 x 1.0	12.3	-- -	27.8:	-
2541	11.1	+49 15	S⁺ IV	--	af	0.28	4.9 x 2.2	11.88	28.8	-- -	-
2545	11.3	+21 30	Sb(t?)	--	g	- --	1.1 x 0.9	13.0	-- -	-- -	-
2549	14.9	+57 58	E6	G4	gk	- --	1.8 x 0.7	12.2	-- -	30.3	-
2551	18.8	+73 35	Sb III: or Sbn	--	-	- --	1.2 x 0.8	13.2	-- -	32.0	-
2552	15.4	+50 11	Ir⁺ IV-V	--	a	- --	2.6 x 2.0	12.5	28.2:	-- -	-
2608	32.2	+28 38	Sc II:	F5	a/af	- --	1.7 x 0.9	12.8	31.8:	31.6	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
2613	$8^h31^m.1$	-22°48'	Sb II	G1	gk	- --	6'.6 x 1'.3	10.9	29.2:	30.7	-
2633	42.7	+74 18	SBbp	--	f	- --	2.0 x 1.1	12.8	-- -	31.9	-
2639	40.1	+50 24	Sa	G5	-	- --	1.2 x 0.6	12.6	-- -	32.6	-
2642	38.3	-03 57	S(B)b I	--	-	- --	1.8 x 1.8	12.7	32.5	33.1	-
2646	44.6	+73 40	?	--	-	- --	0.5 x 0.3	13.1	-- -	32.8	-
2654	44.3	+60 28	Sb⁻ II-III	G5	-	- --	3.7 x 0.5	12.6	30.8	30.8	-
2655	49.4	+78 25	Snn	G1	-	0.65	5.0:x 3.4:	10.92	-- -	30.8	-
2672	46.6	+19 16	E1	G4	-	- --	0.8 x 0.7	13.2	-- -	33.1	-
2681	50.0	+51 31	Sa or Snn	F8	k	0.59	2.8 x 2.5	11.33	-- -	29.4	-
2683	49.6	+33 38	Sb⁻ II-III	G0	g	0.72	8.0 x 1.3	10.53	28.8	27.3:	-
2685	52.2	+58 59	Sbp II-III:	G5	k	0.57	3.0:x 1.6	12.04	30.3:	29.9	-
2693	53.5	+51 33	Ep	G2	k	- --	0.8 x 0.6	13.2	-- -	33.5	-
2701	55.5	+53 59	Sc II	--	a/af	- --	1.6 x 1.0	12.5	31.5	-- -	-
2712	56.2	+45 07	Sb⁺ I	G1	fg	- --	2.3 x 1.1	12.8	32.8	31.3	-
2713	54.8	+03 08	Sb II	--	g	- --	3.2 x 1.0	12.7	31.6	-- -	-
2715	$9^h02.0$	+78 16	Sc* II	--	af	0.34	4.4 x 1.1	11.87	30.8	30.6	-
2732	07.3	+79 24	SD:	--	k	- --	1.3 x 0.5	12.7	-- -	31.8	-
2742	03.7	+60 41	Sc II	--	af	- --	2.5 x 1.0	12.5	31.5	-- -	-
2748	08.2	+76 41	Sc	--	af	- --	2.3 x 0.8	12.3	-- -	31.1	-
2749	02.5	+18 31	E2	G0	k	- --	0.8 x 0.6	13.5	-- -	33.0	-
2763	04.5	-15 17	S⁻ IV:	--	-	0.32	1.7 x 1.7	12.57	29.2:	-- -	-
2764	05.4	+21 39	E?	--	-	- --	0.9 x 0.5	13.3	-- -	-- -	-
2768	07.8	+60 16	E5	G5	k:	- --	2.0 x 1.0	11.2	-- -	30.9	-
2775	07.7	+07 15	Sa or Sb⁻ II:	G3	gk	- --	2.3 x 1.9	11.3	-- -	29.9	-
2776	08.9	+45 11	Sc II	--	f	- --	2.1 x 1.6	11.9	31.0	32.1	-
2781	09.1	-14 36	Sb⁺ II-III	--	-	- --	3.2 x 1.3	12.7	30.7	-- -	-
2782	10.9	+40 19	Sbnt or Sbnp	F0:	g	- --	- - x 1.6	12.5	-- -	32.0	*
2784	10.1	-23 58	E8	--	k	- --	3.0 x 1.1	11.8	-- -	28.2:	-
2787	14.9	+69 25	Sap:	G5	k	- --	2.0 x 1.3	12.0	-- -	29.3	-
2793	13.7	+34 39	Scp	--	af	- --	0.8 x 0.8	12.9	-- -	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
2798	$9^h14^m.4$	+42°10'	S(nn?)t	F5:	-	- --	2'.3 x 0'.6	13.1	-- -	31.2	-
2811	13.9	-16 06	Sb^+ II-III	G3	-	- --	1.6 x 0.5	12.4	30.4	31.8	-
2815	14.1	-23 24	Sbp III: or N	--	-	- --	3.0 x 0.7	12.9	-- -	-- -	-
2832	16.8	+33 59	Et	G0	-	- --	- - - -	13.5	-- -	34.2	-
2835	15.7	-22 08	Sp	--	-	- --	5.8 x 2.8	12.0:	-- -	29.0	*
2841	18.6	+51 12	Sb^- I	G0	k	0.64	6.4 x 2.4	10.10	30.2	29.2	-
2844	18.6	+40 22	Sa	--	g	- --	0.9 x 0.5	13.0	-- -	-- -	-
2848	17.8	-16 18	S^- IV:	--	-	- --	2.1 x 1.4	12.8	29.5:	-- -	-
2855	19.1	-11 41	E1 or Sa	G3	-	- --	1.1 x 1.0	12.6	-- -	31.1	-
2859	21.3	+34 44	SBa	G3	k	- --	4.4 x 3.5	12.0	-- -	31.1	-
2865	21.2	-22 58	E4	G2	-	- --	0.8 x 0.5	12.5	-- -	31.9	-
2880	25.7	+62 44	E3	G4	k	- --	1.0 x 0.7	12.6	-- -	31.0	-
2889	24.8	-11 25	Sb^+(t?) I-II:	--	-	- --	1.3 x 1.2	12.4	31.8:	-- -	-
2902	28.5	-14 30	E0	--	-	- --	0.5 x 0.5	13.1	-- -	-- -	-
2903	29.3	+21 44	Sb^+ I-II	F0	f	0.39	11.0 x 4.6	9.48	29.0	28.6:	-
2907	29.3	-16 32	Sb^-	--	-	- --	1.0 x 0.8	12.9	-- -	-- -	-
2911	31.0	+10 22	E2p	F8	-	- --	0.6 x 0.5	13.6	-- -	32.4	-
2924	32.8	-16 11	E0	--	-	- --	0.5 x 0.5	13.2	-- -	-- -	-
2935	34.5	-20 54	$S(B)b^-$ I	--	-	- --	3.2 x 2.4	12.4	32.2	-- -	-
2942	36.2	+34 14	Sb II:	--	af	- --	1.5 x 1.2	12.9	32.0:	-- -	-
2950	39.1	+59 05	Sap	G2	k	- --	1.3 x 0.9	11.9	-- -	30.8	-
2955	38.3	+36 07	Sb II	--	fg	- --	1.2 x 0.6	13.1	32.2	-- -	-
2962	38.3	+05 24	Sb^+ III	--	g	- --	2.1 x 1.5	12.9	30.5	-- -	-
2964	40.0	+32 05	Scn II:	F5:		0.43	2.2 x 1.1	11.89	31.0:	30.5	-
2967	39.5	+00 34	Sc* III:	--	-	- --	2.2 x 2.0	12.4	30.3:	31.6	-
2968	40.3	+32 10	Pec	--	-	0.93	1.2 x 0.8	12.79	-- -	-- -	-
2974	40.0	-03 29	Sa	G5	-	- --	1.5 x 0.9	11.9	-- -	31.3	-
2976	43.2	+68 08	SD	--	a	0.55	3.5 x 1.3	10.73	-- -	26.53	-
2983	41.3	-20 15	SBa	G5	-	- --	1.8 x 1.0	12.6	-- -	31.2	-
2985	46.0	+72 31	Sb^- I	G3	fg	0.53	5.5 x 5.0	11.11	31.1	30.8	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
2986	$9^h42^m.0$	-21°03'	E1	G7	-	- --	1'.0 x 0'.9	12.2	-- -	31.6	-
2989	43.1	-18 09	Sb^+ II	--	-	- --	1.0 x 0.7	13.1	32.0	-- -	-
2990	43.6	+05 57	SD?	--	a	- --	1.0 x 0.5	13.0	-- -	-- -	-
2992	43.3	-14 06	Pectt	--	-	- --	- - - -	13.0	-- -	-- -	-
2993	43.4	-14 08	Pectt	--	-	- --	- - - -	13.0	-- -	-- -	*
2998	45.8	+44 19	Sc II	--	f	- --	3.9 x 1.1	12.8	31.9	-- -	-
3003	45.6	+33 39	S(B)c III-IV:	F0	a:	0.22	5.0 x 0.9	12.04	29.7:	30.8	-
3021	48.0	+33 47	Sb	--	af	- --	1.1 x 0.5	12.7	-- -	-- -	-
3031	51.5	+69 18	Sb I-II	G3	k	0.76	21.0:x 9.8	7.85	27.4	26.53	-
3032	49.2	+29 28	Sa	G2	g:	- --	0.9 x 0.7	12.8	-- -	30.9	-
3034	51.9	+69 56	Pec	A5	a	0.72	9.0:x 4.0:	9.20	-- -	26.53	-
3041	50.3	+16 55	Sc II-III:	--	af	- --	2.7 x 1.5	12.7	31.3:	-- -	-
3043	52.8	+59 32	Sb^-:	--	-	- --	1.1 x 0.4	13.2	-- -	-- -	-
3044	51.0	+01 49	Sc:	--	a	- --	4.6 x 0.5	12.6	-- -	-- -	-
3052	52.0	-18 24	Sc II	--	-	- --	1.7 x 1.1	12.8	31.7	-- -	-
3054	52.1	-25 28	Sb II-III:	--	-	- --	3.3 x 1.3	12.6	30.6:	-- -	-
3055	52.7	+04 31	Sc II:	--	af	- --	1.7 x 1.0	12.6	31.6:	31.2	-
3065	57.7	+72 25	Sa	--	f:	- --	0.5 x 0.5	12.9	-- -	31.7	-
3067	55.4	+32 37	Sb^+ III	F2	a?	- --	1.8 x 0.5	12.6	30.3	30.8	-
3077	59.4	+68 58	E2p	--	-	0.59	2.3 x 1.9	10.57	-- -	26.53	*
3078	56.2	-26 41	E3	G0	-	- --	0.6 x 0.4	12.1	-- -	31.7	-
3079	58.6	+55 57	Sbp(t) II:	--	fg	0.43	- - - -	11.10	30.2:	30.5	-
3081	56.8	-22 33	Sb^+ III:	--	-	- --	1.1 x 0.8	12.8	30.2:	-- -	-
3091	57.8	-19 23	E2	--	-	- --	1.0 x 0.8	12.7	-- -	-- -	-
3098	59.5	+24 58	E7	--	k	- --	1.4 x 0.4	13.0	-- -	-- -	-
3109	$10^h00.8$	-25 55	Ir^- IV-V	--	-	- --	12: x 2.0	11.2:	26.7:	26.1:	-
3115	02.8	-07 28	E6	G5	k	- --	4.0:x 1.2	10.2	-- -	28.1:	-
3124	04.2	-19 00	$S(B)b^+$ I:	--	-	- --	3.0 x 2.1	12.8	32.7:	-- -	-
3145	07.7	-12 10	Sb^+ I	--	-	- --	2.4 x 1.0	12.5	32.5	32.8	-
3147	12.8	+73 39	Sb I-II:	G7	fg	- --	3.0 x 2.3	11.3	30.8:	32.3	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
3156	$10^h10^m.1$	+03°22'	E5(p?)	--	-	- ---	1'.0 x 0'.5	13.1	-- -	-- -	-
3158	10.9	+39 00	E2	G3	-	- --	0.6 x 0.5	13.1	-- -	34.2	-
3162	10.7	+22 59	Sc II:	F5	f	- --	2.3 x 2.1	12.3	31.4:	30.45	-
3166	11.2	+03 40	Snn	G1	g	0.71	4.4 x 1.7	11.49	-- -	30.4	-
3169	11.7	+03 43	Sbnt	G5	gk	0.62	- - - -	11.24	-- -	30.2	-
3177	13.9	+21 22	Sb^+ II-III	F8	g	- --	0.8 x 0.7	12.8	31.1	30.45	-
3184	15.2	+41 40	Sc II	F3	af	0.37	5.6 x 5.6	10.28	29.4	28.1:	-
3185	14.9	+21 56	$S(B)b^+$ III:	F5	f	0.63	1.4 x 0.9	12.90	30.6:	30.45	-
3190	15.4	+22 05	Sbnt II-III:	G3	gk	0.79	- - - -	11.96	30.3:	30.45	-
3193	15.7	+22 09	E0	G1	k	0.74	0.9 x 0.9	11.83	-- -	30.45	-
3198	16.7	+45 49	Sc II	--	af	0.32	9.0 x 3.2	10.82	29.9	29.1	-
3200	16.2	-17 44	Sb II	--	-	- --	4.2 x 0.9	12.8	31.8	-- -	-
3203	16.3	-26 27	E8	--	-	- --	2.0 x 0.3	13.2	-- -	-- -	-
3226	20.7	+20 09	E2	G2	-	- --	1.0 x 0.8	12.6	-- -	30.5	-
3227	20.7	+20 07	Sbnt	F3:	-	- --	- - - -	11.3	-- -	30.0	*
3245	24.5	+28 46	E5	G2	-	- --	1.8 x 0.9	11.8	-- -	30.4	-
3254	26.5	+29 45	Sb II	G4	fg	- --	4.4 x 1.0	12.1	31.2	30.3	-
3259	29.2	+65 18	Ir^+p IV:	--	g	- --	1.3 x 0.7	12.9	29.9:	31.5	-
3274	29.6	+27 56	Sc*	--	-	- --	2.0 x 0.7	13.0	-- -	-- -	-
3277	30.2	+28 46	Sb^- II:	F5	g	- --	1.1 x 0.9	12.4	31.5:	30.7	-
3285	31.3	-27 12	Snn	--	-	- --	1.3 x 0.8	13.2	-- -	-- -	-
3287	32.1	+21 55	S* IV?	--	a	- --	- - - -	12.8	-- -	-- -	-
3294	33.4	+37 35	Sc I	--	af	- --	2.6 x 1.2	11.6	31.3	30.8	-
3300	34.0	+14 26	SBa	--	-	- --	1.0 x 0.5	13.1	-- -	-- -	-
3301	34.3	+22 08	Sa	G2	gk	- --	2.5 x 0.6	12.2	-- -	30.5	-
3309	34.3	-27 16	E0	--	-	- --	0.5 x 0.5	12.7	-- -	-- -	-
3310	35.7	+53 46	Ir II	A8:	g?	- --	4.0:x 3.0:	11.3	30.4	30.2	-
3312	34.8	-27 20	Sn	--	-	- --	2.4 x 0.9	13.1	-- -	-- -	-
3319	36.4	+41 56	S(B)c II	--	af	0.22	6.2 x 3.2	11.67	30.8	29.6	-
3320	36.7	+47 40	Sc III-IV	--	af	- --	1.8 x 0.8	12.9	30.6:	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
3329	$10^h40^m.6$	+77°05'	SD:	--	gk	- --	1.2 x 0.6	12.9	-- -	-- -	-
3338	39.5	+14 00	Sb+ II	--	f	0.32	4.5 x 3.0	11.25	30.3	30.4	-
3344	40.7	+25 11	Sc II	F5	f	0.24	7.6 x 6.2	10.38	29.5	28.5:	-
3346	41.0	+15 09	Sc II	--	af	- --	2.2 x 2.0	12.4	31.5	-- -	-
3348	43.5	+73 07	E1	G5	k	- --	0.9 x 0.8	12.0	-- -	32.4	-
3351	41.3	+11 58	S(B)b II	F5	fg	0.65	6.1:x 3.9	10.48	29.6	29.15	-
3353	42.3	+56 14	SD?	--	-	- --	0.8 x 0.5	13.0	-- -	-- -	-
3359	43.4	+63 30	S(B)c II	--	a	0.30	7.0:x 3.5:	10.89	30.0	30.2	-
3367	44.0	+14 01	Sc I	F5	af	- --	1.9 x 1.7	11.9	31.6	32.2	-
3368	44.2	+12 05	Sbp	G0	gk	0.69	5.0:x 4.0:	10.05	-- -	29.15	*
3370	44.5	+17 32	Sc III	--	f	- --	2.4 x 1.2	12.4	30.4	30.6	-
3377	45.1	+14 15	E5	G2	k	- --	1.9 x 1.0	11.3	-- -	29.15	-
3379	45.2	+12 51	E1	G7	k	- --	2.2 x 2.0	10.5	-- -	29.15	-
3384	45.7	+12 54	E7	G5	k?	- --	4.4 x 1.4	10.9	-- -	29.15	-
3389	45.8	+12 48	Sc* III:	--	a	- --	2.3 x 1.0	12.1	30.1:	30.4	-
3395	47.1	+33 15	Sct	--	a	- --	1.5 x 0.9	12.4	-- -	31.2	-
3396	47.2	+33 16	Pec(t)	--	a	- --	- - - -	12.8	-- -	31.0	-
3403	50.1	+73 57	Sb+ III or Ir+ IV?	--	-	- --	- - - -	12.9	-- -	30.7	-
3412	48.3	+13 41	E5	G0	gk	- --	2.4 x 1.1	11.5	-- -	29.15	-
3414	48.6	+28 15	SBa or E	G5	k	- --	1.4 x 1.0	12.0	-- -	30.7	-
3415	48.9	+43 59	E4	--	-	- --	0.8 x 0.5	13.1	-- -	-- -	-
3423	48.7	+06 07	Sc II	--	af	0.22	3.5 x 2.8	11.48	30.6	-- -	-
3430	49.5	+33 14	Sc II:	--	af	- --	3.4 x 2.0	12.0	31.1:	31.2	-
3432	49.7	+36 54	St	--	a	0.24	5.8 x 0.8	11.59	-- -	28.8:	-
3433	49.4	+10 26	Sb I:	--	f	- --	2.5 x 2.2	12.9	33.0:	-- -	-
3437	49.9	+23 11	Sb	--	af	- --	2.1 x 0.5	12.6	-- -	-- -	-
3445	51.6	+57 15	Sc*t	--	a	- --	1.1 x 1.1	12.9	-- -	-- -	-
3448	51.7	+54 34	Snt	--	a?	- --	- - - -	12.6	-- -	-- -	-
3455	51.8	+17 33	Sb(nt)	--	af	- --	2.4:x 1.0:	13.1	-- -	-- -	-
3458	53.0	+57 22	SD:	--	-	- --	0.8 x 0.6	13.0	-- -	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
3464	$10^h52^m.2$	-20°49'	Sb$_+$ II-III	--	-	- --	2.6' x 1.4'	13.2	31.4	-- -	-
3478	56.5	+46 23	Sb$^+$ I-II	--	-	- --	2.2 x 0.8	13.2	32.8	-- -	-
3485	57.4	+15 06	S(B)b$^+$ II:	--	af	- --	1.5:x 1.1:	12.8	31.9:	-- -	-
3486	57.8	+29 15	Sc II	G3	fg	0.32	6.8 x 4.5	11.00	30.1	30.1	-
3489	57.7	+14 10	E6	G0	gk	- --	2.0 x 0.9	11.3	-- -	28.8:	-
3495	58.6	+03 53	Sb II:	--	af	- --	4.0 x 0.8	12.7	31.8:	-- -	-
3504	$11^h00.5$	+28 15	Sb(t?)	F3:	fg/g:	- --	2.2 x 2.2	11.6	-- -	30.8	-
3506	00.6	+11 21	Sc*	--	f	- --	0.8 x 0.7	13.2	-- -	-- -	-
3510	01.0	+29 09	St	--	a	- --	3.5 x 0.4	12.8	-- -	29.1	-
3511	00.8	-22 50	Sc* II:	--	a	- --	4.6 x 2.0	11.9	30.9:	-- -	-
3512	01.3	+28 18	Sc III	--	f	- --	1.2 x 1.0	12.9	30.9	30.8	-
3513	01.1	-22 58	S(B)c* II:	--	af	- --	1.9 x 1.3	12.0	31.0:	-- -	-
3516	03.4	+72 50	E or Sa	F0	-	- --	0.8 x 0.6	12.5	-- -	32.2	*
3521	03.2	+00 14	Sb$^+$ II	G3	f	0.76	7.0:x 4.0:	10.06	29.2	28.9:	-
3547	07.3	+11 00	SD?	--	af	- --	1.1 x 0.8	12.9	-- -	-- -	-
3549	08.2	+53 39	Sb II-III	--	af	- --	2.6 x 0.9	12.8	31.1	-- -	-
3556	08.7	+55 57	Sc*	F0:	a	0.38	7.7 x 1.3	10.57	-- -	29.3	-
3571	08.9	-18 01	Sa	--	-	- --	2.6 x 1.0	13.1	-- -	-- -	-
3583	11.4	+48 39	Sc II	--	fg	- --	2.2 x 1.4	12.2	31.3	-- -	-
3585	10.9	-26 29	E5	G3	k	- --	2.0 x 1.0	11.0	-- -	30.5	-
3593	12.0	+13 06	Sb III	F5	g:	- --	2.5:x 0.9	11.6	29.3	28.87	-
3596	12.4	+15 04	Sc* II	--	f	- --	3.6 x 2.8	12.2	31.3	-- -	-
3605	14.2	+18 18	E3	G3	-	- --	0.7 x 0.5	14.0	-- -	28.9:	-
3607	14.3	+18 20	E1	G3	gk:	- --	1.7 x 1.5	11.0	-- -	29.6	-
3608	14.4	+18 26	E3	G0	k	- --	1.4 x 1.0	12.1	-- -	30.2	-
3610	15.6	+59 04	E2p	G2	k	- --	1.3 x 1.0	11.6	-- -	31.36	-
3611	14.9	+04 50	Sa	F5	gk?	- --	1.5 x 1.1	12.8	-- -	31.0	-
3613	15.7	+58 17	E5	G3	-	- --	1.6 x 0.8	11.7	-- -	31.36	-
3614	15.6	+46 02	Sc II	--	af	- --	4.3 x 1.8	12.9	32.0	-- -	-
3619	16.5	+58 02	Snn:	G3	-	- --	- - - -	12.7	-- -	31.36	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
3623	$11^h16^m.3$	+13°23'	Sbn II:	G0	g	0.74	7'.8 x 1'.5	10.18	29.3:	28.87	-
3626	17.5	+18 38	Sb$^-$n II:	G0	gk	- --	1.6 x 1.1	11.0	30.1:	30.7	-
3627	17.6	+13 17	Sb$^+$n* II:	G2	fg	0.56	- - - -	9.65	28.8:	28.87	-
3628	17.7	+13 53	Sbnt	--	g:	0.63	- - - -	10.23	-- -	28.87	-
3629	17.9	+27 15	Scn* III:	--	af	- --	1.8 x 1.1	12.9	31.0:	-- -	-
3630	17.7	+03 15	E7	--	-	- --	1.5 x 0.5	12.8	-- -	-- -	-
3631	18.3	+53 28	Sc I	--	f	0.39	4.3 x 3.2	10.91	30.6	30.3	-
3637	18.1	-09 58	S(B)a:	--	-	- --	1.1 x 1.0	12.8	-- -	-- -	-
3640	18.5	+03 31	E1	G4	k	- --	1.1 x 1.0	11.6	-- -	30.4	-
3642	19.6	+59 21	Sc(n) I	G0	fg/g	0.28	5.7 x 4.4	11.52	31.2	31.36	-
3646	19.2	+20 27	Sc I	--	af	0.48	3.2 x 1.9	11.82	31.6	33.2	-
3655	20.3	+16 51	SD?	--	af	- --	1.2 x 0.9	12.3	-- -	-- -	-
3659	21.1	+18 05	SD:	--	a?	- --	1.1 x 0.5	12.9	-- -	-- -	-
3664	21.7	+03 35	S(B) IV-V:	--	a	- --	1.3 x 1.3	12.9	28.7:	-- -	-
3665	22.1	+39 02	E2	G1	k	- --	1.6 x 1.2	11.9	-- -	31.5	-
3666	21.9	+11 37	Sb III	--	af	- --	3.7 x 0.8	12.6	30.3	-- -	-
3672	22.5	-09 32	Sb$^+$ II	--	a	- --	3.6 x 1.3	11.8	30.9	31.3	-
3673	22.8	-26 28	S(B)b II	--	-	- --	2.9 x 2.3	12.9	31.9	-- -	-
3675	23.5	+43 52	Sb$^-$ II	G2	g	- --	4.0 x 1.7	11.0	30.1	29.3	-
3681	23.9	+17 09	Snn	G3	g	- --	1.0 x 0.9	12.5	-- -	30.4	-
3683	24.8	+57 09	SD:	--	af:	- --	1.3 x 0.5	13.2	-- -	-- -	-
3684	24.5	+17 18	Scn III	F0	f	- --	2.8 x 1.8	12.3	30.3	30.6	-
3686	25.1	+17 30	Sc(n*) II	F3:	-	- --	2.4 x 1.8	11.7	30.8	29.8	-
3687	25.3	+29 47	Sb$^+$ II-III:	--	-	- --	1.3 x 1.3	13.0	31.4:	-- -	-
3689	25.5	+25 56	Sc II:	--	af	- --	1.0 x 0.8	12.8	32.0:	-- -	-
3690	26.0	+58 49	St + ?t	--	a	- --	- - - -	12.1	-- -	-- -	*
3691	25.5	+17 11	SD	--	-	- --	0.9 x 0.7	13.1	-- -	-- -	-
3705	27.6	+09 33	Sb II-III	--	-	- --	3.5 x 1.2	12.2	30.5	-- -	-
3718	29.9	+53 21	Snnt	G0	f?	0.54	- - - -	11.24	-- -	30.2	-
3720	29.8	+01 05	E0	--	-	- --	0.5 x 0.5	13.0	-- -	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
3726	$11^h30^m.7$	+47°19'	Sc(*) I-II	A8	af	0.30	5'.7 x 3'.4	10.84	30.3	30.0	-
3729	31.0	+53 24	Pec	--	-	0.40	1.8 x 1.3	11.88	-- -	-- -	-
3732	31.7	-09 34	E0	--	-	- --	0.6 x 0.6	12.9	-- -	-- -	-
3735	33.1	+70 48	Sb II:	--	f	- --	3.8 x 0.5	12.6	31.7:	-- -	-
3738	33.1	+54 48	Pec	--	a?	0.19	1.3 x 1.1	12.00	-- -	-- -	-
3756	34.1	+54 34	Sc II	--	af	0.44	3.3 x 1.6	12.05	31.2	-- -	-
3769	35.1	+48 11	Sbn	--	f	- --	2.5 x 0.6	12.5	-- -	-- -	-
3773	35.6	+12 23	E0p	--	-	- --	0.5 x 0.5	13.0	-- -	-- -	-
3780	36.7	+56 33	Sc II	--	af	- --	2.4 x 1.9	12.6	31.7	-- -	-
3782	36.9	+46 44	Scp or SD	--	a	- --	1.2 x 0.7	12.9	-- -	-- -	-
3810	38.4	+11 45	Sc I	G0	f	0.42	3.6 x 2.5	11.30	31.0	29.7	-
3813	38.7	+36 49	SD	--	a	- --	1.7 x 0.8	12.6	-- -	-- -	-
3818	39.4	-05 53	E2(p?)	G5	-	- --	0.8 x 0.6	13.0	-- -	30.6	-
3865	42.7	-08 56	Sbn	--	-	- --	1.6 x 1.0	13.0	-- -	-- -	-
3872	43.2	+14 03	E4	G1	-	- --	0.8 x 0.5	13.0	-- -	32.4	-
3877	43.5	+47 46	Sbn	--	af	- --	4.4 x 0.8	12.0	-- -	-- -	-
3887	44.6	-16 35	Sc* II-III:	--	f	- --	2.8 x 2.2	11.6	30.2:	29.9	-
3888	45.0	+56 15	Sb II-III:	--	f	- --	1.3 x 0.9	13.0	31.3:	-- -	-
3892	45.5	-10 41	S(B)a:	--	-	- --	1.3 x 1.0	12.9	-- -	-- -	-
3893	46.1	+49 00	Scn I:	F2:	-	- --	3.7 x 1.9	11.1	30.8:	30.0	-
3898	46.7	+56 22	Sb^- II	G5	k	- --	2.6 x 1.0	11.7	30.8	30.3	-
3900	46.6	+27 17	Sb^+ III	G1	g	- --	1.7 x 0.8	12.4	30.2	31.1	-
3912	47.5	+26 46	Sb^+ III?	--	-	- --	0.9 x 0.5	13.0	-- -	-- -	-
3917	48.3	+52 06	S(n*)	--	af	- --	4.4 x 0.7	12.8	-- -	-- -	-
3936	49.9	-26 37	Sb III	--	-	- --	3.3 x 0.3	13.0	30.6	-- -	-
3938	50.2	+44 24	Sc I	--	fg	0.31	4.5 x 3.8	10.79	30.5	29.8	-
3941	50.3	+37 16	E3	G7	k:	- --	1.8 x 1.2	11.3	-- -	29.9	-
3945	50.6	+60 57	SBa	G3	gk:	- --	5.2 x 2.2	11.7	-- -	30.6	-
3949	51.1	+48 08	Sbn	G0	f	- --	2.3 x 1.1	11.4	-- -	29.4	-
3952	51.1	-03 43	Pec	--	-	- --	1.0 x 0.4	13.0	-- -	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
3953	$11^h51^m.2$	+52°37'	Sb^+ I or $S(B)b^+$ I	G3	f	0.50	5'.6 x 2'.3	10.71	30.8	30.1	-
3955	51.5	-22 54	Sb III	--	-	- --	2.1 x 0.4	12.8	30.4	-- -	-
3956	51.6	-20 18	S^- IV:	--	-	- --	3.2 x 0.5	12.6	29.5:	-- -	-
3957	51.6	-19 17	E8	--	-	- --	2.5 x 0.5	12.9	-- -	-- -	-
3962	52.2	-13 42	E2	G2	-	- --	1.1 x 0.9	11.9	-- -	31.0	-
3963	52.4	+58 46	Sc I-II	--	af	- --	2.1 x 1.9	12.7	32.1	-- -	-
3976	53.4	+07 02	Sb II	--	g	- --	3.3 x 0.8	12.4	31.5	-- -	-
3981	53.7	-19 37	Sbt	--	-	- --	3.8 x 1.3	12.7	-- -	-- -	-
3982	53.9	+55 24	Sbn	--	f	- --	1.7 x 1.3	11.8	-- -	-- -	-
3985	54.1	+48 37	SD:	--	f/g?	- --	0.9 x 0.6	12.9	-- -	-- -	-
3992	55.0	+53 39	$S(B)b^+$ I	G4	f	0.63	6.2 x 3.5	10.62	30.8	30.3	-
3995	55.2	+32 35	Sct	--	af	- --	2.1 x 0.6	12.9	-- -	32.6	-
3998	55.3	+55 44	E2(p?)	G1	k	- --	1.6 x 1.2	11.6	-- -	30.4	-
4008	55.7	+28 28	Sa	--	k	- --	0.7 x 0.5	12.9	-- -	-- -	-
4013	56.0	+44 13	Sb	--	gk:	- --	4.4 x 0.5	12.7:	-- -	-- -	-
4024	56.0	-18 05	E2	--	-	- --	0.9 x 0.7	12.9	-- -	-- -	-
4026	56.9	+51 14	E8	G5	k	- --	3.6 x 0.7	11.7	-- -	29.9	-
4027	57.0	-18 59	Sct	--	af	- --	2.4 x 2.0	11.6	-- -	-- -	-
4030	57.8	-00 49	Sc I	--	f	- --	3.1 x 2.2	11.2	30.9	30.7	-
4032	58.0	+20 21	Ir III:	--	-	- --	1.1 x 1.0	13.0	31.0:	-- -	-
4033	58.0	-17 34	E5	--	-	- --	1.0 x 0.5	12.8	-- -	-- -	-
4036	58.9	+62 10	E6	G2	k	0.71	2.4 x 0.9	11.48	-- -	30.9	-
4037	58.8	+13 41	S(B) IV?	--	-	- --	1.5 x 1.1	12.8	-- -	-- -	-
4038	59.3	-18 35	Sctt	F0	af	- --	- - - -	10.9	-- -	30.8	*
4041	59.7	+62 25	Sc(*) II	--	g	0.32	2.4 x 1.8	11.48	30.6	-- -	-
4045	$12^h00.2$	+02 15	S(t?)p	--	f	- --	- - - -	12.8	-- -	-- -	-
4047	00.2	+48 55	Sb^+ III:	--	g	- --	1.1 x 1.0	12.8	30.5:	-- -	-
4050	00.4	-16 06	$S(B)b^-$ II:	--	-	- --	2.5 x 1.3	12.5	31.6:	-- -	-
4051	00.6	+44 48	Sc(*) II	A5:	f?	0.55	4.5 x 3.6	10.81	30.0	29.2	*
4062	01.5	+32 10	Sb II:	--	-	- --	3.4 x 1.1	12.1	31.3:	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4064	$12^h01^m.6$	+18°43'	Sb⁻ III	--	af/f	- --	2'.0:x 0'.9	12.8	30.6	29.9	-
4073	01.9	+02 11	E1	--	-	- --	0.7 x 0.6	13.2	-- -	-- -	-
4085	02.8	+50 38	Sb III:	--	-	0.38	2.2 x 0.5	12.79	30.5:	-- -	-
4088	03.0	+50 49	Sc* I-II:	--	a:	0.38	4.5 x 1.4	11.03	30.5:	29.6	-
4094	03.3	-14 16	S⁻ IV	--	-	- --	3.5 x 1.0	13.0	30.0	-- -	-
4096	03.5	+47 45	Sc* II:	--	af	0.22	5.7 x 1.0	10.88	30.0:	-- -	-
4100	03.6	+49 51	Sbn I-II:	--	af	- --	5.0 x 1.2	11.9	31.5:	-- -	-
4102	03.8	+52 59	Sc*t	F8	g	- --	2.2 x 1.0	12.3	-- -	30.0	-
4111	04.5	+43 21	E8	G3	k	0.66	3.3 x 0.6	11.63	-- -	29.7	-
4116	05.1	+02 58	SBc III:	--	af	0.23	3.1 x 1.2	12.29	30.3:	30.28	-
4123	05.6	+03 09	SBb III	--	af	0.30	3.2 x 2.0	11.79	29.5	30.28	-
4124	05.6	+10 40	Sa:	--	fg	- --	3.3 x 0.9	12.5	-- -	30.28	-
4125	05.7	+65 27	E5p	G5	k	- --	2.2 x 1.1	11.0	-- -	30.9	-
4128	06.1	+69 03	Sa:	--	k	- --	1.6 x 0.4	12.9	-- -	32.0	-
4129	06.3	-08 45	SD?	--	-	- --	2.2 x 0.3	12.9	-- -	-- -	-
4136	06.7	+30 12	Sc(n) III	F8	-	- --	3.4 x 2.8	12.1	30.2	28.2:	-
4138	07.0	+43 58	E4	G2	g	- --	1.3 x 0.8	12.3	-- -	30.2	-
4143	07.1	+42 49	E4	G5	k	- --	1.4 x 0.9	12.1	-- -	29.6	-
4144	07.5	+46 44	Sb III to S⁻ IV	--	af	- --	5.2 x 0.7	12.4	29.8	-- -	-
4145	07.5	+40 10	Sc* II	--	-	- --	5.4 x 3.1	12.2	31.4	-- -	-
4150	08.0	+30 41	E2	G2	-	- --	1.2 x 0.9	12.6	-- -	28.20	-
4151	08.0	+39 41	Pec	A8:	gk	- --	- - - -	11.3	-- -	30.0	*
4152	08.1	+16 19	Sc(n?) II-III:	--	f	- --	1.7 x 1.3	12.7	31.4:	30.28	-
4157	08.6	+50 46	Sb⁺ II:	--	fg	- --	6.5 x 0.8	12.0	31.1:	-- -	-
4158	08.6	+20 27	Sa	--	fg	- --	0.9 x 0.8	12.9	-- -	-- -	-
4160	09.1	+44 01	S⁻ IV:	--	-	- --	4.4 x 0.4	12.6	29.6:	-- -	-
4162	09.4	+24 24	Sc II	--	f	- --	2.0 x 1.0	12.6	31.8	32.0	-
4168	09.8	+13 29	E0	--	-	0.87	1.0 x 1.0	12.32	-- -	30.28	-
4178	10.2	+11 09	SBc II:	--	af	0.27	4.4 x 1.1	11.75	30.9:	30.28	-
4179	10.3	+01 35	E8	F8	k	- --	2.7 x 0.6	11.7	-- -	30.28	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4189	$12^h11^m.2$	+13°42'	Sc II:	--	-	0.60	1'.7 x 1'.5	12.51	31.7:	30.28	-
4190	11.1	+36 54	Ir	--	-	- --	1.1 x 0.8	13.2	-- -	-- -	-
4192	11.3	+15 11	Sbt I-II:	G0	fg	0.63	8.4 x 1.9	10.89	30.5:	30.28	-
4203	12.5	+33 29	Ep	G3	k	- --	1.8 x 1.5	11.5	-- -	30.0	-
4212	13.1	+14 11	Sc III	--	-	0.57	2.3 x 1.3	11.71	29.8	30.28	-
4214	13.1	+36 36	Ir^+ III-IV	Em	a	0.21	6.6:x 5.8:	10.12	27.9	28.20	-
4215	13.4	+06 41	Sb^+ III:	--	-	- --	1.1 x 0.4	12.8	30.5:	30.28	-
4216	13.4	+13 25	Sb II	G3	g	0.88	7.4 x 0.9	10.88	30.0	30.28	-
4217	13.3	+47 22	Sb	--	g:	- --	4.5 x 0.9	11.9:	-- -	-- -	-
4220	13.7	+48 10	Sa:	G2	fg	- --	2.6 x 0.8	12.2	-- -	30.1	-
4224	14.0	+07 44	Sa or Sb^- III	--	-	0.97	1.5 x 0.6	12.89	-- -	30.28	-
4233	14.6	+07 54	E or Sa	--	-	0.95	1.0:x 0.4	13.03	-- -	30.28	-
4234	14.6	+03 58	SB^+ IV	--	-	- --	0.8 x 0.7	13.0	30.0	30.28	-
4235	14.6	+07 28	Sa or Snn	--	fg/g	0.89	2.6 x 0.5	12.58	-- -	30.28	-
4236	14.3	+69 45	SB^+ IV or Ir^+ IV	--	a	0.15	20.0:x 5.0	10.05	27.0	26.53	-
4237	14.7	+15 36	SD	--	-	- --	1.3 x 0.8	12.6	-- -	30.28	-
4242	14.9	+45 54	S^- IV	--	af	0.31	3.6 x 3.0	11.39	28.4	28.20	-
4244	15.0	+38 05	S^- IV:	--	af:	0.22	14.5:x 1.0	10.48	27.5:	28.20	-
4245	15.2	+29 53	$S(B)b^+$ III	G0	g	- --	1.5 x 1.0	12.4	30.2	29.58	-
4251	15.7	+28 27	E7 or Sa	G3	-	- --	2.3 x 0.8	11.6	-- -	29.58	-
4254	16.3	+14 42	Sc I	G2	f	0.41	4.6 x 3.9	10.37	30.1	30.28	-
4256	16.4	+66 01	Sb:	--	gk	- --	4.0 x 0.5	13.0	-- -	32.2	-
4258	16.5	+47 35	Sb^+(t?)p	G0:	g	0.46	19.5:x 7.0:	8.90	-- -	28.20	*
4260	16.8	+06 23	SBb^- III:	--	gk	- --	2.0 x 0.9	12.7	30.4:	30.28	-
4261	16.8	+06 06	E2	G7	k	- --	0.9 x 0.7	11.7	-- -	30.28	-
4262	17.0	+15 09	E1	--	-	- --	0.9 x 0.8	12.6	-- -	30.28	-
4267	17.2	+13 03	E2 or Sa	G3	-	- --	- - - -	12.0	-- -	30.28	-
4270	17.3	+05 44	Sa	G5	-	0.83	1.2 x 0.4	13.13	-- -	30.28	-
4273	17.4	+05 37	Sc*t III:	F5:	f	0.44	1.5 x 1.0	12.35	30.4:	30.28	-
4274	17.4	+29 53	Sb^+ II-III	G3	g	0.79	6.7 x 1.3	11.33	29.7	29.58	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4278	$12^h17^m.7$	+29°34'	E1	G5	k	0.71	1'.4 x 1'.3	11.20	- --	29.58	-
4281	17.8	+05 40	E5	G3	-	0.89	1.1 x 0.6	12.32	-- -	30.28	-
4283	17.9	+29 35	E0	G8	k	0.75	0.7 x 0.7	13.27	-- -	29.58	-
4290	18.5	+58 22	SBb(n?) II	--	f	- --	1.6 x 1.2	12.7	31.8	-- -	-
4291	18.1	+75 40	E1	G3	k	- --	0.8 x 0.7	12.4	-- -	31.5	-
4293	18.7	+18 40	Pec	--	fg:	- --	4.6 x 1.6	11.7	-- -	30.28	-
4294	18.7	+11 47	S(B)c* III-IV:	--	-	0.32	2.4 x 0.9	12.46	30.2:	30.28	-
4298	19.0	+14 53	S**t	--	af	0.51	2.2 x 1.1	11.95	-- -	30.28	-
4299	19.2	+11 47	S* IV: or Ir^+ IV:	--	-	0.18	1.1 x 0.9	12.71	29.8:	30.28	-
4302	19.2	+14 53	Sc	--	f	0.74	4.7 x 0.5	12.44	-- -	30.28	-
4303	19.4	+04 45	Sc I	G1	f	0.30	5.6 x 5.3	10.01	29.8	30.28	-
4307	19.5	+09 20	Sb^- II-III	--	-	- --	2.8 x 0.4	13.0	31.4	30.28	-
4314	20.0	+30 10	SBa	G2	-	- --	3.1 x 2.9	11.5	-- -	29.58	-
4321	20.4	+16 06	Sc I	F5	fg	0.56	5.3 x 4.5	10.07	29.8	30.28	-
4324	20.6	+05 31	Sb^+ III?	G5	gk	- --	1.3 x 0.6	12.5	-- -	30.28	-
4339	21.0	+06 22	E0	G3	k	- --	0.7 x 0.7	12.6	-- -	30.28	-
4340	21.0	+17 00	SBa	--	k	- --	2.2 x 1.4	13.0	-- -	30.28	-
4342	21.1	+07 22	Sa:	--	k	0.82	2.1 x 0.3	13.48	-- -	30.28	*
4346	21.0	+47 16	E6	--	k	- --	1.9 x 0.7	12.4	-- -	-- -	-
4348	21.3	-03 10	Sb II-III:	--	-	- --	2.8 x 0.4	13.1	31.4:	-- -	-
4350	21.4	+16 58	E7	G5	gk	- --	1.8 x 0.5	11.9	-- -	30.28	-
4365	22.0	+07 36	E2	G5	k	- --	1.3 x 1.0	11.1	-- -	30.28	-
4369	22.1	+39 39	Sa	--	af:	- --	1.4 x 1.3	12.4	-- -	30	-
4371	22.4	+11 59	SBa	--	-	0.86	2.2:x 1.2	11.83	-- -	30.28	-
4374	22.6	+13 10	E1	G5	-	0.79	1.6 x 1.4	10.21	-- -	30.28	-
4377	22.7	+15 02	E1	--	k	- --	0.7 x 0.6	12.9	-- -	30.28	-
4378	22.8	+05 12	Snn	--	gk	- --	3.0 x 2.7	12.8	-- -	30.28	-
4379	22.8	+15 53	E1	--	-	- --	0.7 x 0.6	13.0	-- -	30.28	-
4380	22.9	+10 17	Snn	--	-	- --	2.6 x 1.3	12.8	-- -	30.28	-
4382	22.8	+18 28	Ep or Et	G5	gk	0.72	2.1 x 1.7	10.05	-- -	30.28	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4383	$12^h23^m.0$	+16°45'	E:p	--	-	- --	0'.8 x 0'.5	12.9	-- -	30.28	-
4385	23.1	+00 50	SBb⁻ II-III	--	fg	- --	1.1 x 0.9	12.9	31.2	30.28	-
4386	22.4	+75 48	Sa:	--	-	- --	1.0 x 0.5	12.8	-- -	31.5	-
4388	23.3	+12 56	Sbn	--	-	0.61	5.0 x 0.9	11.73	-- -	30.28	-
4389	23.1	+45 58	SB⁻ IV?	--	af	- --	1.7 x 0.9	12.8	-- -	-- -	-
4394	23.4	+18 29	SBb⁻ II	G3	g	0.76	2.3 x 2.3	11.81	31.0	30.28	-
4395	23.4	+33 49	S⁺ IV-V	--	a	0.31	10.0:x 8.0	10.66	26.5:	28.20	-
4406	23.7	+13 13	E3	G7	k	0.79	2.1 x 1.4	10.10	-- -	30.28	-
4412	24.0	+04 14	S(B)p	--	a	- --	0.9 x 0.8	12.8	-- -	30.28	-
4414	24.0	+31 30	Scn* II:	G2	fg	- --	3.2 x 1.5	10.9	30.1:	29.58	-
4417	24.3	+09 52	E7	--	-	0.72	1.8 x 0.5	12.11	-- -	30.28	-
4419	24.4	+15 19	Ep	--	-	- --	2.2 x 0.6	12.2	-- -	30.28	-
4420	24.4	+02 46	Sc* III:	--	a	- --	1.9 x 0.7	12.5	30.5:	30.28	-
4424	24.6	+09 42	Sbn III:	--	-	0.51	2.0 x 1.0	12.32	30.1:	30.28	-
4425	24.7	+13 01	Sb⁻ III:	G2	-	0.82	2.0 x 0.5	12.84	30.6:	30.28	-
4428	24.9	-07 54	Sc* III:	--	-	- --	1.5 x 0.6	13.1	31.1:	30.28	-
4429	24.9	+11 23	?	G3	fg	0.88	3.3 x 1.0	11.09	-- -	30.28	-
4433	25.0	-08 01	SD	--	-	- --	1.5 x 0.6	12.9	-- -	30.28	-
4435	25.2	+13 21	E4	G5	k	0.77	1.3 x 0.8	11.86	-- -	30.28	-
4438	25.3	+13 17	Snntt	G3	g?	0.66	- - - -	10.92	-- -	30.28	-
4442	25.6	+10 05	E5p	G5	k	0.81	1.8 x 0.9	11.61	-- -	30.28	-
4448	25.8	+28 54	Sb⁻ II-III	G2	g	- --	2.8 x 1.0	11.7	30.1	29.58	-
4449	25.8	+44 22	Ir III	FO:	a	0.18	4.1 x 3.4	9.90	28.0	28.20	-
4450	25.9	+17 21	Sbn	G3	g	0.64	3.0 x 2.5	10.81	-- -	30.28	-
4452	26.2	+12 02	S	--	-	- --	1.3 x 0.3	13.2	-- -	30.28	-
4454	26.3	-01 40	Sb⁺ II-III:	--	-	- --	1.3 x 1.1	12.8	31.1:	30.28	-
4455	26.2	+23 06	S⁺ IV:	--	-	- --	2.4 x 0.5	13.0	30.1:	-- -	-
4457	26.4	+03 51	S(B)a	--	g	- --	2.4 x 2.0	11.7	-- -	30.28	-
4459	26.5	+14 15	E2	G3	-	- --	1.2 x 1.0	11.5	-- -	30.28	-
4460	26.4	+45 08	E8	--	fg?	- --	2.0 x 0.5	12.5	-- -	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4461	$12^h26^m.6$	+13°28'	Sa	G5	gk	- --	1'.6 x 0'.7	12.0	-- -	30.28	-
4462	26.7	-22 54	Sb III:	--	-	- --	2.7 x 0.8	13.0	30.6:	-- -	-
4469	27.0	+09 02	Sp	--	fg:	- --	2.9 x 0.8	12.5	-- -	30.28	-
4472	27.3	+08 16	E4	G7	k	0.78	2.8 x 1.8	9.33	-- -	30.28	-
4473	27.3	+13 42	E4	G7	k	- --	1.6 x 0.9	11.3	-- -	30.28	-
4474	27.4	+14 21	E6	G3	-	- --	1.3 x 0.5	12.7	-- -	30.28	-
4476	27.5	+12 37	E4 or Sa	--	-	- --	0.7 x 0.4	13.4	-- -	30.28	-
4477	27.6	+13 55	S(B)a	G3	-	- --	2.4 x 2.2	11.4	-- -	30.28	-
4478	27.8	+12 36	E1	G5	-	- --	0.8 x 0.7	12.3	-- -	30.28	-
4483	28.2	+09 17	S(B)a?	--	-	- --	0.8 x 0.5	13.3	-- -	30.28	-
4485	28.2	+41 58	Ir III-IV:	--	-	0.16	1.5 x 0.8	12.24	30.0:	-- -	-
4486	28.3	+12 40	E1	G5	k	0.76	1.9 x 1.8	9.56	-- -	30.28	-
4487	28.3	-07 48	Sc II-III	--	-	- --	3.3 x 2.5	12.0	30.6	30.28	-
4490	28.3	+41 55	Scn*t III:	A5	af	0.22	5.6 x 2.1	10.09	28.1:	28.20	-
4494	28.9	+26 03	E1	G7	k	- --	1.3 x 1.2	10.9	-- -	30.6	-
4496	29.1	+04 12	S(B)c III: + ?	--	a+a	0.40	3.3 x 2.7	11.93	30.0:	30.28	-
4501	29.5	+14 42	Sb^+ I	G5	fg	0.53	5.5 x 2.4	10.07	30.2	30.28	-
4503	29.6	+11 27	E:2	--	gk	- --	0.8 x 0.6	12.8	-- -	30.28	-
4504	29.7	-07 17	Scn II-III:	--	-	- --	5.8 x 1.8	12.3	30.9:	30.28	-
4517	29.0	+00 21	Sc	--	af	0.54	8.9 x 0.9	11.10	-- -	30.28	-
4519	31.0	+08 56	Sc III	--	af	0.32	2.2 x 1.7	12.22	30.3	30.28	-
4522	31.2	+09 27	Scp	--	-	- --	2.5 x 0.5	12.9	-- -	30.28	-
4526	31.6	+07 58	E7	G4	g	- --	3.3:x 1.0	10.6	-- -	30.28	-
4527	31.6	+02 56	Sb^+(n) II	G2	g	0.71	5.3 x 1.0	11.29	30.4	30.28	-
4532	31.8	+06 44	Ir: III:	--	a?	0.17	2.2 x 0.5	12.17	30.2:	30.28	-
4535	31.8	+08 28	S(B)c I:	F0:	af	0.45	6.0 x 4.0	10.38	30.1:	30.28	-
4536	31.9	+02 28	Sc(t) II:	--	f	0.39	6.9 x 2.6	10.94	30.1:	30.28	-
4540	32.3	+15 50	Ir IV	--	af	- --	1.0 x 0.8	12.9	30.0	30.28	-
4546	32.9	-03 31	E6	G3	gk	- --	1.8 x 0.8	11.4	-- -	30.28	-
4548	32.9	+14 46	SBbn	G5	g	0.48	3.7 x 3.2	10.86	-- -	30.28	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4550	$12^h32^m.9$	+12°30'	E7	G3	-	- --	1'.4 x 0'.4	12.6	-- -	30.28	-
4552	33.1	+12 50	E0	G7	k	- --	1.3 x 1.3	11.0	-- -	30.28	-
4559	33.5	+28 14	Sc II-III	--	a	0.23	11.0:x 4.5	10.26	28.9	29.7	-
4561	33.6	+19 36	Sc* III-IV:	--	af	- --	1.0 x 1.0	12.9	30.7:	-- -	-
4564	34.0	+11 43	E6	--	-	0.78	1.6 x 0.6	12.17	-- -	30.28	-
4565	33.9	+26 16	Sb I:	G0	gk	0.68	14.4 x 1.2	10.30	30.5:	30.4	-
4567	34.0	+11 32	Sc**t	--	f	0.58	- - - -	11.98	-- -	30.28	-
4568	34.1	+11 31	Sc**t	--	af	0.71	- - - -	11.66	-- -	30.28	*
4569	34.3	+13 26	Sb$^+$n	G0	f	0.43	7.5:x 2.2	10.11	-- -	30.28	-
4570	34.4	+07 31	E8	G7	k	- --	2.4 x 0.5	11.8	-- -	30.28	-
4571	34.3	+14 28	Snn*	--	-	0.31	2.6 x 2.2	11.63	-- -	30.28	-
4578	35.0	+09 50	Sa	G0	-	- --	1.9:x 1.3:	12.5:	-- -	30.28	-
4579	35.1	+12 05	Sbn	G3	gk	0.65	4.4 x 3.5	10.32	-- -	30.28	-
4580	35.3	+05 38	Sb$^+$n III	--	-	- --	1.3 x 1.0	12.8	30.5	30.28	-
4586	35.9	+04 35	Sb$^+$ III	--	f	0.85	2.6 x 0.7	12.54	30.3	30.28	-
4589	35.6	+74 28	Sa or Ep	G5	k	- --	1.0 x 0.8	12.1	-- -	31.5	-
4592	36.7	-00 16	Sb II-III	--	-	- --	2.8 x 0.8	12.4	30.7	30.28	-
4593	37.0	-05 04	SBb$^-$ II	--	-	- --	3.5 x 2.7	12.1	31.2	30.28	-
4594	37.3	-11 21	Sb$^-$	G3	k	0.81	6.0 x 2.5	9.18	-- -	30.28	-
4595	37.3	+15 34	Sc* III:	--	-	- --	1.1 x 0.8	13.1	31.2:	30.28	-
4596	37.4	+10 27	SBa	--	k	0.84	2.8:x 2.2:	11.41	-- -	30.28	-
4597	37.5	-05 32	SBc* III:	--	-	- --	3.7 x 1.1	12.9	30.9:	30.28	-
4602	38.0	-04 52	Scn* II:	--	-	- --	- - - -	12.4	31.5:	30.28	-
4605	37.8	+61 53	SD	--	a?	- --	5.0 x 1.2	10.9	-- -	26.53	-
4608	38.7	+10 26	SBa	--	k	0.80	1.4 x 1.4	12.02	-- -	30.28	-
4612	39.0	+07 35	Ep	--	k	- --	0.9 x 0.8	12.6:	-- -	30.28	-
4618	39.2	+41 25	Sc*t	--	a	0.19	3.5 x 3.0	11.08	-- -	28.20	-
4621	39.5	+11 55	E3	G7	k	- --	1.4 x 1.0	11.0	-- -	30.28	-
4623	39.6	+07 56	E:5	--	-	- --	1.1 x 0.6	13.2	-- -	30.28	-
4630	40.0	+04 14	Pec	--	-	- --	1.1 x 0.8	13.1	-- -	30.28	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4631	$12^h39^m.8$	+32°49'	Sc* III?	Em	a/af:	0.36	12'.6 x 1'.4	9.71	-- -	28.20	-
4632	40.0	+00 11	Sc* II-III	--	af	- --	2.6 x 0.8	12.1	30.7	30.28	-
4635	40.2	+20 12	N?	--	-	- --	1.5 x 0.9	13.0	-- -	-- -	-
4636	40.3	+02 57	E1	G2	k	- --	1.4 x 1.3	10.8	-- -	30.28	-
4638	40.2	+11 43	E5	G3	g	- --	1.1 x 0.5	12.2	-- -	30.28	-
4639	40.3	+13 31	S(B)b II-III:	--	-	0.52	2.4 x 1.5	12.11	30.5:	30.28	-
4643	40.8	+02 15	SBa	--	k	- --	1.5 x 0.9	11.6	-- -	30.28	-
4647	41.0	+11 51	Sc**	--	f	0.36	2.0 x 1.5	12.05	-- -	30.28	*
4649	41.1	+11 49	E1	G7	k	0.85	2.0 x 1.8	9.88	-- -	30.28	-
4651	41.2	+16 40	Scp II:	--	g	0.37	3.0 x 2.5	11.21	30.4:	30.28	-
4653	41.4	-00 18	S^- IV-V or N	--	-	0.31	2.2 x 1.9	12.69	-- -	30.28	-
4654	41.4	+13 23	Sc(*) II	--	a	0.47	4.2 x 2.2	11.03	30.2	30.28	-
4656	41.6	+32 26	Sctt	--	a	0.18	19.5 x 2.0	10.74	-- -	29.4	-
4658	42.1	-09 49	Sc(*) III	--	-	- --	1.3 x 0.5	12.4	30.4	30.28	-
4660	42.0	+11 26	E5	G2	-	- --	1.5 x 0.8	12.1	-- -	30.28	-
4665	42.6	+03 19	S(B)a	G3	k	- --	3.1 x 2.1	11.8	-- -	30.28	-
4666	42.6	-00 12	Sc I-II:	--	g	0.50	3.8 x 0.8	11.40	30.8:	30.28	-
4668	43.0	-00 17	Pec	--	-	0.24	0.8 x 0.6	13.44	-- -	30.28	-
4670	42.8	+27 23	Ep	--	k?	- --	0.9 x 0.7	12.7	-- -	-- -	-
4682	44.7	-09 48	S^- IV?	--	-	- --	1.4 x 0.8	13.1	-- -	30.28	-
4684	44.7	-02 28	Sa	--	-	- --	1.8 x 0.5	12.2	-- -	30.28	-
4688	45.3	+04 36	S IV	--	-	- --	2.2 x 2.2	13.0	30.0	30.28	-
4689	45.2	+14 01	Sb^+ II:	--	f	0.47	2.4 x 1.9	11.48	30.6:	30.28	-
4691	45.6	-03 04	Snn	--	-	- --	2.2 x 1.7	11.8	-- -	30.28	-
4694	45.7	+11 15	E5	--	gk:	- --	1.8 x 0.9	12.6	-- -	30.28	-
4697	46.0	-05 32	E4	G4	g	- --	2.2 x 1.4	10.4	-- -	30.28	-
4698	45.8	+08 45	Sb^- II:	G3	k	0.77	3.0 x 1.1	11.56	30.7:	30.28	-
4699	46.5	-08 24	Sa or Snn*	--	k	- --	3.0 x 2.0	10.2	-- -	30.28	-
4700	46.5	-11 08	SD?	--	-	- --	2.2 x 0.3	12.2	-- -	30.28	-
4701	46.6	+03 39	Sn	--	fg	- --	2.2:x 1.6	12.8	-- -	30.28	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4710	$12^h47^m.1$	+15°26'	E8	--	g	- --	3.'3 x 0.'5	12.0	-- -	30.28	-
4712	47.2	+25 44	S IV	--	f	0.37	1.8 x 0.9	13.46	30.5	-- -	-
4713	47.5	+05 35	Sc* III	--	af	- --	2.2 x 1.3	12.3	30.3	30.28	-
4725	48.1	+25 46	S(B)b I	G4	g	0.55	10.0:x 5.5	10.07	30.2	30.2	-
4731	48.4	-06 08	SBcp II-III:	--	-	- --	5.5 x 3.0	12.2	30.8:	30.28	-
4736	48.6	+41 23	Sb⁻p II:	G0	g:	0.57	- - - -	8.91	28.1:	28.20	*
4742	49.2	-10 12	E3	G0	-	- --	0.9 x 0.6	12.5	-- -	30.28	-
4747	49.4	+26 01	Pec(t)	--	-	0.44	- - - -	12.90	-- -	-- -	-
4750	48.4	+73 09	Sap or Sbp	--	fg	- --	1.7 x 1.5	12.2	-- -	31.3	-
4753	49.8	-00 55	Snn or Ep	--	-	- --	3.3:x 1.1	10.7	-- -	30.28	-
4754	49.7	+11 35	Et?	G4	-	- --	2.0 x 1.2	11.6	-- -	30.28	-
4756	50.3	-15 08	E2	--	-	- --	0.5 x 0.4	13.3	-- -	30.28	-
4760	50.5	-10 13	E2	--	-	- --	0.6 x 0.5	12.5	-- -	30.28	-
4762	50.4	+11 31	Snnt:	G2	gk	- --	- - - -	11.0	-- -	30.28	-
4763	50.6	-16 43	Sa	--	-	- --	0.9 x 0.6	13.2	-- -	-- -	-
4765	50.7	+04 45	SD:	--	-	- --	0.7 x 0.5	12.9	-- -	30.28	-
4771	50.8	+01 33	Sb III	--	f	- --	2.8 x 0\5	12.9	30.6	30.28	-
4772	51.0	+02 27	Sa or Snn	--	-	- --	2.3 x 1.0	12.6	-- -	30.28	-
4775	51.1	-06 21	Sc(*) III	--	a	- --	1.7 x 1.6	11.6	29.6	30.28	-
4781	51.8	-10 16	Sc* II-III	--	a	- --	2.3 x 1.1	11.7	30.3	30.28	-
4782	51.9	-12 11	E0(t?)	--	-	- --	0.5 x 0.5	12.9:	-- -	30.28	-
4783	52.0	-12 12	E0(t?)	--	-	- --	0.5 x 0.5	12.7:	-- -	30.28	-
4786	52.0	-06 35	E2p	--	-	- --	0.6 x 0.5	12.7	-- -	30.28	-
4790	52.2	-09 58	Sc* III:	--	-	- --	1.2 x 0.9	12.5	30.5:	30.28	-
4793	52.3	+29 13	Sc III	--	-	- --	2.3 x 1.1	12.3	30.4	32.0	-
4795	52.5	+08 20	Snnt:	--	-	- --	1.5 x 1.0	13.1	-- -	30.28	-
4800	52.4	+46 48	SD	F8	-	- --	1.2 x 1.0	12.3	-- -	29.6	-
4808	53.3	+04 35	Sc* III	--	af	- --	2.2 x 0.8	12.5	30.5	30.28	-
4814	53.3	+58 37	Sbp II:	G3	g	- --	2.2 x 2.1	12.8	31.9:	32.1	-
4818	54.3	-08 15	S(B)nn?	--	-	- --	3.1 x 0.9	12.1	-- -	30.28	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
4825	$12^h54^m.3$	-13°24'	E2p	--	-	- --	0'.6 x 0'.5	12.9	-- -	30.28	-
4826	54.3	+21 57	?	G7	fg	0.70	6.5 x 3.2	9.27	-- -	27.8:	*
4845	55.5	+01 51	Sb III	--	fg	- --	4.2 x 0.7	12.6	30.3	30.28	-
4856	56.7	-14 46	S(B)a or Et	G5	k	- --	2.0 x 0.7	11.4	-- -	30.28	-
4861	56.7	+35 08	Ir IV-V	--	a	- --	3.9 x 0.9	12.9	28.8:	29.6	-
4866	57.0	+14 27	Sb^- III:	G3	-	- --	6.8 x 0.8	12.0	29.8:	30.28	-
4868	56.8	+37 35	Sb^+ II:	--	-	- --	1.1 x 1.0	13.1	32.3:	-- -	-
4880	57.7	+12 45	Sa or Snn	--	-	- --	2.2 x 1.3	13.1	-- -	30.28	-
4889	57.7	+28 15	E4	G2	-	- --	1.0 x 0.6	13.2	-- -	34.12	*
4891	58.1	-13 09	N	--	-	- --	1.6 x 1.4	13.0	-- -	30.28	-
4899	58.3	-13 41	Sp	--	-	- --	1.8 x 1.0	12.7	-- -	30.28	-
4900	58.2	+02 46	Sc* III or Ir III	--	a	- --	1.7 x 1.5	11.9	29.9	30.28	-
4902	58.3	-14 15	SBb I	--	af	- --	2.1 x 2.0	11.7	31.8	32.1	*
4904	58.4	+00 15	S(B)c(n*)	--	af	- --	1.7 x 1.0	12.8	-- -	30.28	-
4914	58.4	+37 35	E2(p?)	--	-	- --	1.0 x 0.8	13.0	-- -	-- -	-
4915	58.8	-04 16	Sa	G5	-	- --	0.8 x 0.7	13.0	-- -	32.4	-
4928	$13^h00.3$	-07 49	S^+* IV	--	-	- --	0.9 x 0.6	12.9	29.9	30.28	-
4933	01.2	-11 14	Ep(t?)	--	-	- --	- - - -	12.8	-- -	30.28	-
4939	01.7	-10 05	N	--	-	- --	5.0 x 1.9	12.2	-- -	30.28	-
4941	01.6	-05 17	Sbp	F8:	-	- --	- - - -	12.0	-- -	30.28	*
4951	02.5	-06 14	Sn*:	--	-	- --	4.0 x 1.0	12.7	-- -	30.28	-
4958	03.1	-07 45	E6	G3	k	- --	1.7 x 0.7	11.5	-- -	30.28	-
4961	03.4	+28 00	Sc III:	--	f	- --	1.0 x 0.7	13.2	31.3:	-- -	-
4981	06.1	-06 31	Sc II-III	--	-	- --	2.0 x 1.5	12.2:	30.8:	-- -	-
4984	06.4	-15 15	Snn	--	gk	- --	1.1 x 0.9	11.9	-- -	-- -	-
4995	07.0	-07 34	Sbn	--	f	- --	2.0 x 1.1	11.9	-- -	31.2	-
4999	07.2	+01 55	N?	--	fg	- --	1.8 x 1.6	12.8	-- -	-- -	-
5005	08.5	+37 19	Sb^- II	G0	g	0.57	4.4 x 1.7	10.52	29.7	30.2	-
5012	09.3	+23 11	Sb II	--	f	- --	2.2 x 1.2	12.6	31.8	-- -	-
5016	09.7	+24 21	Sb II-III	--	f	- --	1.2 x 0.8	12.8	31.2	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
5017	$13^h10^m.3$	-16°30'	E2	--	-	- --	0'.5 x 0'.4	13.3	-- -	-- -	-
5018	10.3	-19 15	Sa	G7	-	- --	1.7 x 1.0	12.2	-- -	32.2	-
5033	11.2	+36 51	Sb^+t I-II:	G1	g	0.37	9.9 x 4.8	10.61	30.3:	30.0	-
5037	12.4	-16 20	Sb^+ III	--	-	- --	1.6 x 0.5	13.1	30.8	-- -	-
5044	12.8	-16 08	E0	--	-	- --	0.9 x 0.9	12.2	-- -	-- -	-
5054	14.3	-16 23	Sbnt II:	--	f	- --	3.8 x 2.2	11.9	31.0:	-- -	-
5055	13.5	+42 17	Sb^+ II	F8	g	0.55	10.0:x 5.0:	9.26	28.4	28.20	-
5061	15.3	-26 36	E2	--	k	- --	1.2 x 0.9	11.7	-- -	31.4	-
5068	16.2	-20 47	S(B)c III-IV	--	a	- --	5.6 x 5.6	11.6:	29.2:	28.1:	-
5074	16.2	+31 44	Pec?	--	-	- --	0.5 x 0.5	13.2	-- -	-- -	-
5077	16.9	-12 24	E3	G2	-	- --	0.9 x 0.6	12.6	-- -	32.0	-
5084	17.5	-21 34	E8:	--	-	- --	6.6:x 1.0	12.4	-- -	-- -	-
5085	17.6	-24 09	Sb II-III or Sbn	--	-	- --	2.8 x 2.0	12.3	-- -	-- -	-
5087	17.7	-20 21	E4	G2	-	- --	1.0 x 0.6	12.1	-- -	31.1	-
5088	17.7	-12 19	Sc* II:	--	-	- --	2.0 x 0.6	13.2	32.3:	-- -	-
5101	19.0	-27 11	SBa or SBb^- I-II	--	-	- --	5.6 x 4.7	12.5	-- -	-- -	-
5112	19.6	+39 00	Sc* II?	--	a	- --	3.3 x 2.1	12.6:	-- -	-- -	-
5116	20.5	+27 14	Sb^-	--	af:	- --	1.5 x 0.7	12.9	-- -	-- -	-
5134	22.6	-20 51	Sb^+ III	--	-	- --	1.8 x 0.8	12.4	30.0	-- -	-
5147	23.7	+02 22	Sc(*) II-III	--	a/af	- --	1.4 x 1.0	12.1	30.7	-- -	-
5170	27.1	-17 42	Snn:	--	-	- --	7.6 x 0.7	12.6	-- -	-- -	-
5172	26.9	+17 19	Sb^+ I-II	--	fg	- --	2.2 x 1.3	12.5	32.2	-- -	-
5194	27.8	+47 27	Sc(t) I	F8:	f	0.46	10.0:x 5.5	8.88	28.6	28.20	-
5195	27.9	+47 31	Pec(t)	F5	-	0.92	- - - -	10.47	-- -	28.20	-
5198	28.2	+46 56	E2	G2	k	- --	0.6 x 0.5	12.9	-- -	32.1	-
5204	28.3	+58 40	Ir^+ IV	--	f	0.19	3.9 x 2.2	11.62	28.6	28.20	-
5230	33.0	+13 56	Sc I-II	--	af	- --	1.6 x 1.5	12.9	32.4	-- -	-
5247	35.3	-17 38	Sb^+ I-II	--	f	- --	4.4 x 3.7	11.9	31.4	-- -	-
5248	35.1	+09 08	Sc I	F8	f	0.36	6.1 x 4.4	10.36	30.1	30.3	-
5273	39.9	+35 55	E1(p?)	F0:	gk	- --	0.9 x 0.8	12.6	-- -	30.2	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
5297	$13^h44^m.3$	+44°05'	Sb^+ I	--	-	- --	5'.2 x 0'.8	13.0	32.2	-- -	-
5300	45.7	+04 11	Sc II	--	-	- --	3.1 x 2.1	12.3	31.4	-- -	-
5301	45.0	+46 24	Sb II-III:	--	-	- --	3.4 x 0.5	13.0	31.3:	31.3	-
5308	45.4	+61 14	E8	G5	k	- --	2.1 x 0.5	12.5	-- -	31.7	-
5313	47.7	+40 13	Sb II:	--	-	- --	1.3 x 0.7	13.0	32.2:	-- -	-
5322	47.6	+60 26	E2	G8	k	- --	1.4 x 1.1	11.1	-- -	31.6	-
5324	49.4	-05 48	Sc II-III	--	-	- --	1.7 x 1.6	12.6	31.2	-- -	-
5326	48.7	+39 49	Sb^- III	--	-	- --	1.5 x 0.4	13.1	30.8	-- -	-
5334	50.4	-00 53	S^- IV-V	--	-	- --	3.3 x 2.2	12.5	28.3:	-- -	-
5347	51.1	+33 43	$S(B)b^+$ III	--	-	- --	1.1 x 0.9	13.2	31.0	-- -	-
5350	51.2	+40 37	Sb I	--	f	- --	2.1 x 1.3	12.9	33.0	-- -	-
5351	51.2	+38 09	Sb^+ II	--	af	- --	2.4 x 1.1	13.0	32.2	-- -	-
5353	51.3	+40 31	E5	G3	-	- --	1.3 x 0.6	12.1	-- -	31.8	-
5362	52.8	+41 30	Sbn	--	-	- --	1.8 x 0.7	13.2	-- -	-- -	-
5363	53.6	+05 29	Ep	G0	-	0.79	2.0 x 1.4	11.13	-- -	30.2	-
5364	53.7	+05 15	Sb^+p I	G2	fg	0.46	6.2 x 3.0	11.04	31.2	30.7	-
5371	53.6	+40 43	Sb^+ I	G3	f	- --	3.4 x 3.2	11.4	31.5	32.2	-
5376	53.6	+59 45	Sa:	--	fg	- --	1.2 x 0.8	13.0	-- -	-- -	-
5377	54.3	+47 27	Sap	F8	gk	- --	- - - -	12.0	-- -	31.4	*
5380	54.8	+37 51	Sa	--	-	- --	0.5:x 0.5:	13.2	-- -	-- -	-
5383	55.0	+42 05	SBb II	--	fg:	- --	2.0 x 1.9	12.7	31.8	-- -	-
5395	56.5	+37 39	Sb^+t I:	--	af	- --	2.1 x 1.0	12.4	32.6:	-- -	-
5406	58.2	+39 09	Sb^+ I-II	--	-	- --	1.4 x 1.0	13.0	32.6	-- -	-
5422	59.0	+55 24	E9	--	gk	- --	2.9 x 0.4	13.0	-- -	-- -	-
5426	$14^h00.8$	-05 49	Sct	--	-	0.42	1.9 x 1.1	12.71	-- -	-- -	-
5427	00.8	-05 47	Sc(t) I	--	-	0.44	2.0 x 1.6	11.98	31.7	-- -	-
5430	59.1	+59 34	Sb(n)t	--	f	- --	1.9 x 1.0	12.8	-- -	-- -	-
5444	01.2	+35 22	E1	--	-	- --	0.7 x 0.6	13.1	-- -	-- -	-
5448	00.9	+49 25	Sb^+ II-III	G2	fg	- --	4.0 x 1.2	12.1	30.4	31.6	-
5457	01.4	+54 35	Sc I	F8	f	0.23	22.0:x20.0:	8.20	27.9	28.20	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
5468	$14^h\ 4^m\!.0$	-05°14'	Sc II	--	-	- --	2'.0 x 1'.9	12.4	31.5	32.2	-
5473	3.0	+55 08	E2	G3	-	- --	0.9 x 0.7	12.4	-- -	31.7	-
5474	3.2	+53 54	Scn*t	--	f	0.24	4.0:x 2.9	11.22	-- -	28.20	-
5480	4.6	+50 57	Sc**t I-II:	--	f	- --	1.1 x 0.9	12.6	32.0:	-- -	-
5485	5.5	+55 14	Sa:	G5	-	- --	0.8 x 0.7	12.4	-- -	31.6	-
5493	8.9	-04 49	?	G5	-	- --	0.8 x 0.5	12.5	-- -	32.0	-
5496	9.0	-00 56	S^- IV:	--	-	- --	3.8 x 0.5	12.8	29.8:	-- -	-
5523	12.6	+25 34	Sb II-III	--	f	- --	3.9 x 0.8	12.8	31.2	-- -	-
5533	14.1	+35 35	Snn	G0	gk	- --	1.8 x 0.8	12.6	-- -	32.9	-
5534	15.0	-07 11	St	--	-	- --	- - - -	13.0	-- -	-- -	-
5548	15.7	+25 22	Snn?(t?)p:	F5:	g?	- --	- - - -	13.3	-- -	33.5	*
5557	16.4	+36 43	E1	G3	-	- --	0.9 x 0.8	12.2	-- -	32.6	-
5566	17.8	+04 11	Sb^+nt II-III:	G5	gk?	- --	5.6:x 1.1	11.4	29.7:	30.8	-
5574	18.4	+03 28	?	G0	gk	- --	0.9 x 0.3	13.4	-- -	31.1	-
5576	18.5	+03 30	E2	G1	k	- --	1.0 x 0.8	12.0	-- -	30.9	-
5584	19.8	-00 10	Sc II'	--	-	- --	2.6 x 2.0	12.2	31.3	-- -	-
5585	18.0	+56 57	S IV	--	fg	0.28	5.5 x 3.0	11.25	28.3	28.20	-
5595	21.5	-16 30	Sct	--	-	- --	1.4 x 0.8	12.4	-- -	-- -	-
5597	21.7	-16 33	Sbn	--	-	- --	1.3 x 1.1	12.6	-- -	-- -	-
5600	21.4	+14 52	Sct:	--	f	- --	1.0 x 0.9	12.4	-- -	-- -	-
5605	22.3	-12 57	Sc I	--	-	- --	1.3 x 1.0	13.1	32.7	-- -	-
5614	22.0	+35 05	Snt	G4	g	- --	- - - -	12.6	-- -	33.0	-
5631	25.1	+56 48	Sa or Ep	G3	-	- --	0.7 x 0.7	12.5	-- -	31.7	-
5633	25.6	+46 22	SD	F5	g	- --	0.8 x 0.6	12.9	-- -	32.0	-
5638	27.1	+03 27	E1	G3	k	- --	0.9 x 0.9	12.4	-- -	31.1	-
5641	27.1	+29 02	S(B)b^- I-II:	--	-	- --	2.1 x 0.9	13.1	32.7:	-- -	-
5645	28.1	+07 29	Scn* II-III:	--	f	- --	2.0 x 1.0	12.9	31.5:	-- -	-
5653	28.0	+31 25	Sn:	--	g	- --	1.2 x 0.9	12.9	-- -	32.8	-
5660	28.1	+49 50	Sc* II	--	af	- --	1.8 x 1.7	12.3	31.4	-- -	-
5665	29.9	+08 18	Scn*t	--	f	- --	1.1 x 0.9	12.7	-- -	-- -	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
5668	$14^h30^m.9$	+04°40'	Sc* II-III	F0	f	- --	2'.5 x 2'.3	12.2	30.8	31.2	-
5669	30.3	+10 08	Sc III	--	af	- --	3.3 x 2.4	12.5	31.6	-- -	-
5676	31.0	+49 41	Sc* II:	--	f	- --	3.0 x 1.3	11.7	30.8:	31.9	-
5678	30.7	+58 08	Sc(p?) II:	--	f	- --	2.3 x 1.2	12.1	31.2:	32.0	-
5687	33.3	+54 42	Sa:	G3	k	- --	1.0 x 0.6	12.8	-- -	31.8	-
5689	33.7	+48 57	Snn:	G2	k	- --	- - x 0.5	12.9	-- -	31.9	-
5690	35.2	+02 30	Sb II-III	--	a	- --	2.8:x 0.6	12.9	31.2	-- -	-
5691	35.3	-00 11	Sn?	--	-	- --	1.1 x 0.8	13.0	-- -	-- -	-
5701	36.7	+05 34	S(B)b⁻ I-II	--	k	- --	4.0 x 3.4	12.8	32.4	-- -	-
5713	37.6	-00 05	Scn*	F2:	a	- --	2.0 x 1.8	11.8	-- -	31.4	-
5728	39.6	-17 03	S(B)b⁻ II	--	-	- --	2.0 x 0.8	12.4	31.4	-- -	-
5739	40.6	+42 03	Snn	--	-	- --	- - - -	13.1	-- -	-- -	-
5740	41.9	+01 54	Sb⁺ II-III	--	-	0.57	2.2 x 1.0	12.55	30.8	-- -	-
5746	42.3	+02 10	Sb(n?)	G2	gk	0.86	6.2 x 0.8	11.57	-- -	31.3	-
5750	43.6	-00 01	Sb⁺ III	--	-	- --	1.6 x 0.8	12.6	30.3	-- -	-
5756	44.9	-14 39	Scp	--	-	- --	1.3 x 0.6	13.1	-- -	-- -	-
5757	45.0	-18 53	SBbn:	--	-	- --	1.3 x 1.2	12.6	-- -	-- -	-
5768	49.6	-02 20	Ir⁺ IV:	--	-	- --	1.4 x 0.6	12.9	29.9:	-- -	-
5775	51.5	+03 45	Sb or Sc	--	fg:	0.63	3.6 x 0.5	12.15	-- -	-- -	-
5791	56.0	-19 04	Sa	--	-	- --	1.0 x 0.6	13.0	-- -	-- -	-
5792	55.8	-00 54	Sb(n?)p	--	-	- --	6.6 x 1.0	12.9:	-- -	-- -	-
5796	56.6	-16 26	E0	--	-	- --	0.7 x 0.7	12.8	-- -	-- -	-
5806	57.5	+02 05	Sb⁺ III:	G0	g	- --	1.8 x 0.8	12.4	30.1:	31.28	-
5812	58.2	-07 16	E1	G7	-	- --	0.8 x 0.7	12.6	-- -	31.5	-
5813	58.7	+01 54	E1	G5	k	- --	0.9 x 0.8	12.0	-- -	31.28	-
5820	57.2	+54 05	E5(t?)	G4	-	- --	1.0 x 0.5	13.4	-- -	32.7	-
5831	$15^h01.6$	+01 24	Ep	G5	k	- --	0.6 x 0.5	12.7	-- -	31.28	-
5838	02.9	+02 18	Sa	G2	gk	- --	3.2 x 0.7	11.7	-- -	31.28	-
5846	04.0	+01 48	E0	G0	k	0.78	0.9 x 0.9	11.16	-- -	31.28	-
5850	04.6	+01 44	SBb⁻ I	G4	g	0.50	2.6 x 2.2	11.56	31.6	31.28	-

NGC	$\alpha(1950)$	$\delta(1950)$	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
5854	$15^h05^m.3$	+02°45'	Sa:	G1	gk	- --	1'.8 x 0'.4	12.6	-- -	31.28	-
5861	06.4	-11 08	Scp I?	--	-	- --	2.3 x 1.1	12.4	-- -	-- -	-
5864	07.0	+03 14	E7p	--	gk	- --	1.7 x 0.5	12.8	-- -	-- -	-
5866	05.1	+55 57	E6p	G2	k	- --	2.8 x 1.0	10.9	-- -	30.0	-
5878	11.0	-14 05	Snn	G8	-	- --	2.9 x 0.9	12.4	-- -	31.6	-
5879	08.4	+57 12	Sb II-III	F8	g	- --	4.5 x 1.1	12.2	30.5	30.1	-
5885	12.4	-09 53	S^- IV-V?	--	-	- --	2.4 x 2.4	12.4	-- -	-- -	-
5898	15.2	-23 55	E1(p?)	G2	-	- --	0.8 x 0.7	12.6	-- -	31.7	-
5899	13.2	+42 14	Sb^{+*} I:	F5:	f	- --	- - - -	12.5	32.6:	32.2	-
5903	15.6	-23 51	E1	G3	-	- --	0.8 x 0.7	12.7	-- -	32.0	-
5905	14.1	+55 42	S(B)b I:	--	f	- --	4.4 x 3.2	13.1	33.2:	-- -	-
5907	14.6	+56 31	Sb^+ II:	G3	g	0.55	11.1 x 0.7	11.04	30.1:	29.3	-
5908	15.4	+55 36	Sb^-	--	g	- --	2.4 x 0.4	13.0	-- -	-- -	-
5915	18.8	-12 55	Sb^+t or Sct	--	-	- --	1.1 x 0.8	12.5	-- -	-- -	-
5921	19.5	+05 15	S(B)b^+ I-II	G0	fg	- --	3.6 x 3.0	11.7:	31.3:	30.8	-
5936	27.6	+13 09	Sc I:	--	af	- --	1.0 x 0.9	12.9	32.6:	-- -	-
5949	27.2	+64 55	SD	--	af	- --	2.0 x 0.8	12.9	-- -	28.8:	-
5962	34.2	+16 46	Sc II	G0	f	- --	2.4 x 1.8	11.9	31.0	31.6	-
5970	36.1	+12 20	Sc II-III	F8	g	- --	2.3 x 1.6	12.4	31.0	31.7	-
5982	37.6	+59 32	E3(p?)	G7	k	- --	1.2 x 0.8	12.3	-- -	32.5	-
5984	40.6	+14 22	Sb II-III:	--	-	- --	2.6 x 0.5	13.0	31.3:	-- -	-
5985	38.6	+59 30	Sb I	G0	fg	- --	4.9 x 2.2	11.9	32.0	32.1	-
6015	50.7	+62 28	Sc II	F8	af	0.36	5.6 x 1.7	11.69	30.7	29.8	-
6052	$16^h03.1$	+20 41	?	--	a?	- --	0.8 x 0.6	13.0	-- -	-- -	-
6070	07.4	+00 50	Sc I	F8	f	- --	3.2 x 1.8	12.3	31.9	31.7	-
6106	16.3	+07 31	Sb^+ II-III:	--	f	- --	2.1 x 1.0	12.9	31.1:	-- -	-
6118	19.3	-02 11	Sb II	--	-	- --	4.3 x 1.3	12.3	31.2	-- -	-
6181	30.1	+19 56	Sc I	G2	f	- --	2.0 x 0.9	12.3	31.9	31.8	-
6207	41.3	+36 56	Sc II:	F8:	-	- --	2.0 x 1.1	12.3	31.3:	30.2	-
6217	34.8	+78 18	Sc* I-II	F8:	af:	- --	- - - -	11.8	31.1	31.0	-

NGC	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
6239	$16^h48^m.4$	+42°50'	Sbt	--	af	- --	2.1' x 0.8'	12.9	-- -	-- -	-
6340	$17^h11.1$	+72 22	Sap or Snn:	G3	g	- --	2.0 x 1.8	12.0	-- -	31.9	-
6384	29.9	+07 06	Sb I:	G5	gk	0.46	5.0:x 4.0:	11.23	30.9:	31.4	-
6412	30.8	+75 45	Sc II	--	af	0.27	1.9 x 1.5	12.19	31.1	31.2	-
6482	49.8	+23 05	E3(p?)	G0	k	- --	0.9 x 0.6	12.2	-- -	33.1	-
6503	49.9	+70 10	Sb III:	--	af	0.41	4.5:x 1.0	10.77	28.3:	27.3:	-
6574	$18^h09.5$	+14 58	SD:	F8	f	- --	0.9 x 0.7	12.8	-- -	32.1	-
6643	21.2	+74 33	Sc, I-II	G0	-	0.39	3.0 x 1.3	11.61	30.8	31.3	-
6814	$19^h39.9$	-10 25	Sb^+ I	F0:	..	- --	2.0 x 2.0	12.2	31.8	31.0	*
6822	42.1	-14 53	Ir IV-V	Em	-	- --	16.2:x11.2:	9.21	24.6:	-- -	-
6835	51.8	-12 42	E8	--	-	- --	2.0 x 0.3	13.0	-- -	-- -	-
6907	$20^h22.1$	-24 58	S(B)b I-II:	--	-	- --	2.5 x 2.2	12.1	31.6:	-- -	-
6946	33.9	+59 58	Sc I or (Sc II)	F5	af	0.41:	9.0:x 7.5:	9.67	-- -	27.6:	-
6951	36.5	+65 56	Sbp I-II:	--	f:	0.51	3.3 x 2.3	11.84	30.8:	31.1	-
7137	$21^h45.9$	+21 56	SD:	--	f	- --	0.9 x 0.9	13.1	-- -	31.2	-
7171	58.3	-13 31	Sb^+ II	G0	-	- --	2.1 x 0.9	13.1	32.2	32.2	-
7177	58.3	+17 29	Sb^- II or Sbn	G0	g	- --	2.1 x 1.1	12.0:	-- -	30.7	-
7184	59.9	-21 04	Sb^+ II-III	--	-	- --	5.1 x 0.9	12.0	30.3	-- -	-
7217	$22^h05.6$	+31 07	Sb^- II?	G7	gk	0.63	2.6 x 2.3	11.00	-- -	30.4	-
7218	07.5	-16 54	Sc III-IV	--	-	- --	2.1 x 0.7	12.7	30.4	31.4	-
7252	18.0	-24 56	Et or Pec	F3	-	- --	- - - -	13.1	-- -	33.4	-
7300	28.3	-14 17	Sb^+ I-II:	--	-	- --	1.9 x 0.8	13.2	32.8:	-- -	-
7302	29.7	-14 23	E3	G7	-	- --	0.9 x 0.6	13.1	-- -	32.2	-
7309	31.6	-10 37	Sc II	--	-	- --	1.4 x 1.1	13.1	32.2	-- -	-
7314	33.0	-26 18	Sc(*) I-II	F8:	af	- --	3.9 x 1.9	11.6	31.0	31.3	-
7331	34.8	+34 10	Sb I-II	G8	gk	0.54	10.0 x 2.3	10.27	29.5	30.3	-
7332	35.0	+23 32	E7	G3	k?	- --	2.3 x 0.6	11.8	-- -	30.8	-
7371	43.4	-11 16	Sb III:	--	-	- --	1.0 x 1.0	12.9	30.6:	-- -	-
7377	45.1	-22 35	E1 or Sa	G2	-	- --	0.9 x 0.8	12.4	-- -	32.7	-
7392	49.2	-20 53	Sb II:	--	-	- --	1.5 x 0.8	12.6	31.7:	32.4	-

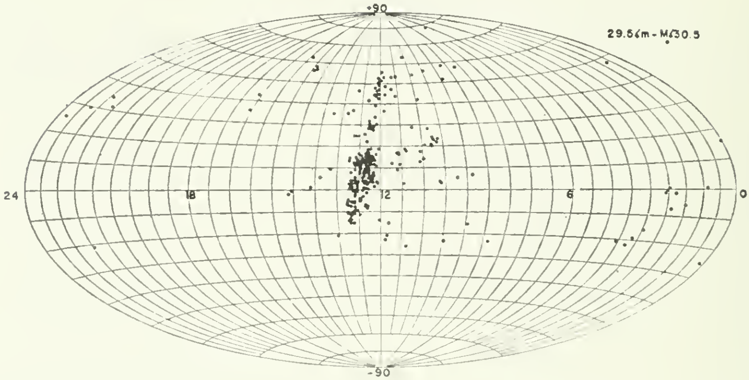
Name	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter ′ ′	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
NGC 7448	$22^h57^m.6$	+15°43′	Sc*(t) II:	G2	fg	- --	2.0 x 1.0	11.9	30.9:	32.1	-
7457	58.6	+29 53	Ep	G2	gk	- --	1.9 x 1.0	12.6:	-- -	29.5	-
7469	$23^h00.7$	+08 36	Snn$^+_:$	F5:	g?	- --	1.3 x 1.0	12.7	-- -	33.5	*
7479	02.4	+12 03	SBb$^+$ I	G3	f	- --	3.4 x 2.6	11.6	31.6	32.1	-
7541	12.2	+04 15	Sc II:	F2	a	- --	2.9 x 0.9	12.6	31.7:	32.3	-
7585	15.4	-04 56	Snn	G0	-	- --	2.0 x 1.5	12.7	-- -	32.7	-
7600	16.3	-07 52	E6	G3	-	- --	1.1 x 0.4	13.0	-- -	32.7	-
7606	16.5	-08 46	Sb$^+$ I	G2	fg	- --	4.4 x 1.5	11.6	31.7	32.0	-
7619	17.8	+07 55	E1	G5	k	- --	1.0 x 0.9	12.4	-- -	33.0	-
7625	18.0	+16 57	Ep	G1	g?	- --	1.0 x 0.8	13.2	-- -	31.5	-
7626	18.2	+07 56	E2(p?)	G3	-	- --	1.0 x 0.8	12.7	-- -	32.8	-
7640	19.7	+40 35	S(B)b$^+$ II:	--	f	0.13	11.0:x 1.4	11.31	30.0:	29.2	-
7678	26.1	+22 09	Sc I	F5:	af	- --	1.7 x 1.1	12.5	32.1	32.8	-
7679	26.2	+03 15	Snn	F5	-	- --	1.4 x 0.8	13.2	-- -	33.6	-
7716	33.9	+00 01	Sb II:	G8	g	- --	1.3 x 1.1	12.9	32.0:	32.2	-
7721	36.2	-06 48	Sc II	--	-	- --	3.0 x 0.9	12.4	31.5	-- -	-
7723	36.4	-13 14	Sbn	--	-	- --	2.2 x 1.6	11.8	-- -	31.6	-
7727	37.3	-12 34	Snn(t?)	G8	-	- --	- - - -	11.6	-- -	31.5	-
7741	41.4	+25 48	SBc II	F2	af	0.30	3.3 x 2.5	11.63	30.6	29.9	-
7742	41.8	+10 29	E0p	G0	gk?	- --	0.9 x 0.9	12.2	-- -	31.4	-
7743	41.8	+09 39	Sa?	G0	gk	- --	1.6 x 1.4	12.3	-- -	31.5	-
7769	48.5	+19 52	Scnt	--	f	- --	1.3 x 1.2	12.5	-- -	33.3	-
7782	51.4	+07 42	Sbn	--	-	- --	2.1 x 0.9	13.1	-- -	-- -	-
7785	52.8	+05 38	E:5	G5	-	- --	1.1 x 0.6	13.0	-- -	33.0	-
7814	$0^h00.7$	+15 51	Sb$^-$	G3	k	- --	6.0:x 1.0	11.7	-- -	30.5	-
IC 749	$11^h56.0$	+43 01	Sc(*) III:	--	-	- --	1.8 x 1.1	13.2	31.2:	-- -	-
750	56.3	+43 00	Sb$^-$n:	--	-	- --	1.7 x 0.6	13.0	-- -	-- -	-
1953	$3^h31.4$	-21 39	Sc* II-III:	--	-	- --	2.1 x 1.9	12.5	31.1:	-- -	-
2537	$10^h01.7$	-27 19	S$^-$ IV-V	--	-	- --	2.1 x 1.5	12.8	28.3:	-- -	-
2627	$11^h07.5$	-23 28	Sb$^+$ II:	--	-	- --	2.0 x 1.6	12.8	31.8:	-- -	-

Name	α(1950)	δ(1950)	Type and Class	Sp	Y	C_o	Diameter	m_{pg}	$m-M_o(M)$	$m-M_o(V)$	N
An I	$1^h02^m.6$	-06°29'	S(B) IV-V	--	-	- --	4'.5 x 3'.4	12.8	28.7:	-- -	*
HA 85	$5^h09.5$	-14 50	N	--	-	- --	2.2 x 1.5	13.1	-- -	-- -	-
R 80	$12^h29.9$	+00 38	S V	--	-	0.24	3.7 x 1.7	12.52	-- -	30.28?	-
An 3	46.8	-09 51	S^- IV-V:	--	-	- --	2.1 x 1.7	12.5	28.3:	30.28?	-
An 4	52.6	+00 23	N?	--	-	- --	2.3 x 1.1	12.9	-- -	30.28	-
F 703	$15^h11.0$	-15 18	S^- IV-V or N	--	-	- --	2.4 x 1.9	12.8	-- -	-- -	-

Remarks

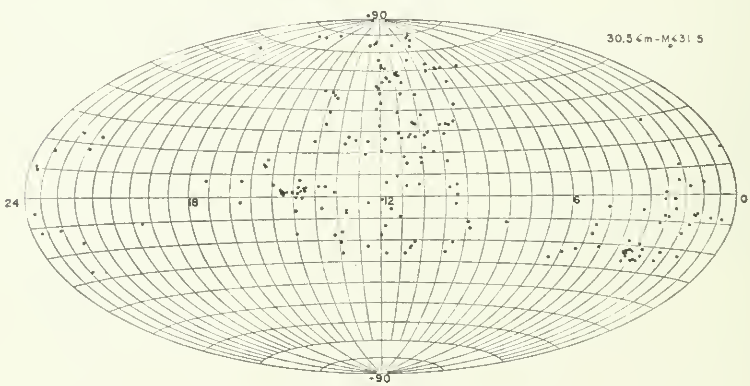
NGC 178 Late type, has one resolved arm.
NGC 275 Interacting with NGC 274.
NGC 474 Fuzzy nucleus surrounded by segments of nebulous ring. Interacting with NGC 470.
NGC 520 Colliding galaxies?
NGC 1068 Seyfert galaxy. Halo.
NGC 1415 Diameter does not include faint "tidal arms".
NGC 2149 Probably galactic reflection nebula.
NGC 2207 Interacting pair.
NGC 2782 Seyfert galaxy.
NGC 2835 Spiral arms of low surface brightness.
NGC 2993 Interacting with NGC 2992.
NGC 3077 Seyfert galaxy.
NGC 3227 Seyfert galaxy.
NGC 3368 This galaxy (M96) is a member of a small class of objects with a bright main body with tightly coiled spiral arms surrounded by a faint halo. Other members of this class are NGC 1068 (M77) and NGC 4736 (M94).
NGC 3516 Seyfert galaxy.
NGC 3690 Two colliding galaxies.
NGC 4038 Colliding with NGC 4039.
NGC 4051 Seyfert galaxy.
NGC 4151 Seyfert galaxy.
NGC 4258 Seyfert galaxy.
NGC 4342 Identification uncertain.
NGC 4568 Interacting with NGC 4567.
NGC 4647 Interacting with NGC 4649.
NGC 4736 M94, has halo similar to those of M77 and M96.
NGC 4826 M64 is a very peculiar object. A blue plate taken with the 74-in. telescope shows tightly wound rather fuzzy spiral arms on which a large obscuring cloud is superimposed. The declination given in H.A. 88 should be increased by 10′.
NGC 4889 In Coma cluster. Misidentified as NGC 4872 in H.A. 88.
NGC 4902 Both radial velocity and luminosity classification place this galaxy beyond the Virgo Cluster.
NGC 4941 The structural peculiarities of this galaxy are similar to, but less pronounced, than those in the Seyfert galaxy NGC 4151.
NGC 5377 Appearance similar to that of NGC 4941 and the Seyfert galaxy NGC 4151.
NGC 5548 Seyfert galaxy.
NGC 6814 Seyfert galaxy.
NGC 7469 Seyfert galaxy.
Anon 1 Has S V companion at $\alpha(1855) = 0^h54^m$, $\delta(1855) = -8° 25'$.

$29.5 \leqslant m-M_0 \leqslant 30.5$ (Figure 3)



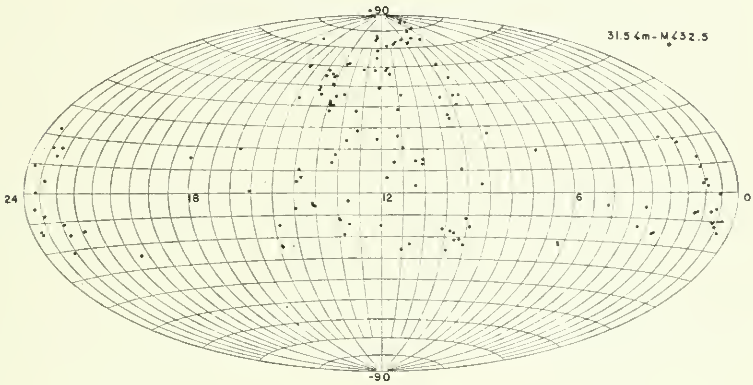
In this distance interval the Virgo cluster is the most prominent feature. Early type galaxies predominate in the nucleus of the cluster at $\alpha \simeq 12^h25^m$, $\delta \simeq + 13°$. A secondary clustering of predominately late type galaxies is located at $\alpha \simeq 12^h20^m$, $\delta \simeq + 5°$. The figure shows the southern extension of the Virgo cluster as a loose grouping of galaxies near $\alpha \simeq 12^h50^m$, $\delta \simeq -10°$. The Ursa Major cluster ($\alpha \simeq 12^h00^m$, $\delta \simeq +50°$) and the NGC 4274 group ($\alpha \simeq 12^h15^m$, $\delta \simeq + 30°$) also show on the figure. The NGC 4274 group is probably somewhat closer to us than the Virgo Cluster. The NGC 3193 group. ($\alpha \simeq 10^h10^m$, $\delta \simeq + 23°$) is possibly associated with the Virgo cluster complex.

$30.5 \leqslant m-M_0 \leqslant 31.5$ (Figure 4)



The figure shows a concentration of galaxies near $\alpha \simeq 14^h40^m$, $\delta \simeq +2°$, which are apparently associated with the NGC 5850 group. The figure also shows a loose clustering of galaxies near $\alpha \simeq 3^h25^m$, $\delta \simeq -23°$.

$31.5 \leqslant m - M_0 \leqslant 32.5$ (Figure 5)



No conspicuous clustering is apparent in this distance interval.

The Luminosity Function of Galaxies

The frequency with which different DDO classification types occur among all Shapley-Ames galaxies north of $\delta = -27°$ is given in Table II.

TABLE II

Frequency of Classification Types

Determined from the classification of 935 Shapley-Ames Galaxies

Type	Frequency
E (including S0)	22.9 per cent.
Sa	7.7
Sb	27.5
Sc (including S IV and S V)	27.3
Ir	2.1
Other	12.5

Luminosity classes could be assigned to about 80 per cent. of all galaxies of types Sb, Sc and Ir.

The number of Shapley-Ames galaxies of different types and luminosity classes is given in Table III.

TABLE III

Observed Frequency of Shapley-Ames Galaxies

Type	Sb	Sc	Ir
Class			
I	37.5	30.5	0
I–II	22	14	0
II	58	68	1
II–III	37	22	0
III	36	31.5	3.5
III–IV	0.5	9.5	2
IV		21	6
IV–V		8.5	4.5
V		1	0

Using the magnitude calibration of Table I the observed frequency distribution of galaxies over the luminosity classes may be converted to relative space densities, if one makes the following assumptions: 1. The distribution of galaxies throughout space is uniform. 2. The degree of completeness of the Shapley-Ames catalogue depends on apparent magnitude only, i.e. the Shapley-Ames catalogue does not discriminate against galaxies of a particular type or luminosity class.

The assumption of a uniform space distribution of galaxies is probably valid for galaxies of luminosity classes I to IV. However, for fainter objects the Shapley-Ames catalogue contains only galaxies in the immediate vicinity of the local group. The space density of galaxies in the vicinity of the local group is probably higher than average. The assumption of a uniform distribution of galaxies will therefore lead to an overestimate of the space density of objects of luminosity classes IV–V and V. This effect is compensated for to some extent by the fact that the Shapley-Ames catalogue is more incomplete for large galaxies of low surface brightness than for small galaxies of high surface brightness. The faint end of the computed luminosity function must however be regarded as quite uncertain.

TABLE IV

RELATIVE SPACE DENSITY OF GALAXIES

Luminosity Classes	Approximate magnitude limits	Sb	Sc	Ir	Total
I, I–II	−20.5 to −19.5	0.9	1.0	0	1.9
II, II–III	−19.5 to −18.5	7.5	4.9	0.04	12.4
III, III–IV	−18.5 to −17.5	11	10	1.3	22.3
IV	−17.5 to −16.5	0	17	4.8	21.8
IV–V	−16.5 to −15.5	0	36:	19:	55:

Table IV gives the relative space densities for galaxies of different types and luminosity classes. The data have been normalized in such a way that they refer to a volume which contains one supergiant galaxy of type Sc. The table shows that the luminosity function of galaxies increases rapidly as one goes to fainter absolute magnitudes. The results for Sc and Ir galaxies are in fair agreement with those obtained by van den Bergh (1960a).

It is of some interest to note that the ratio of the number of spiral galaxies to the number of irregular galaxies increases rapidly as one goes to intrinsically brighter galaxies.

REFERENCES

van den Bergh, S. 1960a, *Ap. J.*, vol. 131, p. 215; 1960b, *Ap. J.* (in press).
Holmberg, E. 1958, *Lund Medd.* II, no. 136.
Humason, M. L., Mayall, N. U., and Sandage, A. R. 1956, *A.J.*, vol. 61, p. 97.
Morgan, W. W. 1958, *Publ. A.S.P.*, vol. 70. p. 364.
Pettit, E. 1954, *Ap. J.*, vol. 120, p. 413.
Shapley, H. and Ames, A. 1932, *Harv. Ann.*, vol. 88, no. 2.
Stebbins, J. and Whitford, A. E. 1952, *Ap. J.*, vol. 115, p. 284.

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THE LUMINOSITY FUNCTIONS OF GALACTIC STAR CLUSTERS

SIDNEY van den BERGH
and DAVID SHER

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THE LUMINOSITY FUNCTIONS OF GALACTIC STAR CLUSTERS

Abstract

The luminosity functions of the following galactic clusters have been obtained down to $m_{pg} \simeq 20$

NGC 188	NGC 663	NGC 2158	NGC 2539
NGC 436	NGC 1907	NGC 2194	NGC 2682 (M67)
NGC 457	NGC 1960 (M36)	NGC 2362 (τ CMa)	NGC 7789
NGC 559	NGC 2099 (M37)	NGC 2477	IC 361
NGC 581 (M103)	NGC 2141	NGC 2506	Trumpler 1

It is found that striking differences exist among the main sequence luminosity functions of individual clusters. Also it appears that the faint ends of the luminosity functions of galactic clusters differ systematically from the van Rhijn-Luyten luminosity function for field stars in the vicinity of the sun in the sense that (with one exception) all the clusters which were investigated to faint enough limits, had luminosity functions which either decreased or remained constant below $M_{pg} = +5$. The differences between individual clusters and the differences between the luminosity functions of clusters on the one hand and field stars on the other show that the luminosity function of star creation is not unique. This result is taken to indicate that the luminosity function with which stars are created probably depends on the physical conditions prevailing in the region of star creation.

It is also shown that the observed surface density of cluster stars may be represented by an exponentially decreasing function of the distance from the cluster centre. In a number of clusters, which have ages larger than their relaxation times, the brightest cluster stars are found to be more strongly concentrated towards the cluster centre than are the faintest stars.

Observational Material

This investigation is based on a series of 170 plates of galactic clusters obtained with the 48-inch Schmidt telescope on Palomar Mountain during nine nights in January and February of 1958*. A series of exposures ranging from 4 seconds to 10 minutes on Kodak 103aO emulsion (no filter) was obtained of each cluster. Also one 5-minute exposure of each cluster was taken on Kodak 103aE emulsion behind a red plexiglass filter. The limiting magnitude of each blue plate was determined from a magnitude sequence which had previously been established within the cluster. On each plate stars were counted in rings centred on the cluster. From these counts the number of

*During the night of January 13/14, 1958, the seeing deteriorated rapidly. All plates taken after 19^h 15^m P.S.T. were subsequently rejected.

cluster stars in each ring down to a given limiting magnitude was determined. By means of this procedure it was possible to investigate the luminosity functions of 20 galactic clusters down to about 20th magnitude.

Counting Procedure

The centre of each cluster was found by inspection and the plate was placed, emulsion downwards, on a sheet of transparent polar graph paper, in such a way that the centre of the cluster coincided with the pole of the co-ordinate system.

The difference in the radii of two consecutive circles of the polar graph paper was 0.1 inches, corresponding to 171″ on the plate. The annuli, henceforth called "rings", thus formed, were numbered 1, 2, 3, etc., from the pole outwards.

Counting stars on a plate is not free from a "personal equation" effect. Innumerable decisions have to be made, rejecting some marks on the plate while accepting others as stars. A comparison between independent counts by the two authors on four plates in M67 is shown in figure 1. The comparison shows that the counts by van den

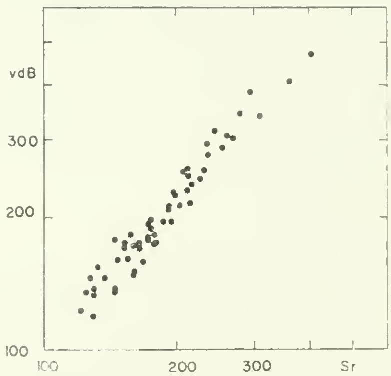


Fig. 1—Comparison of independent counts by van den Bergh and Sher on four plates of M67.

Bergh are systematically higher than those by Sher; that is to say the latter author was more conservative in his judgment of faint markings on the plate. Most of the counts which are reported in this paper have been made by Sher. Multiple counts of the same plate by Sher indicate that the root mean square deviation of two independent series of counts is 3.7 per cent.

An individual's counting limit is likely to vary somewhat over a period of time. To reduce, as much as possible, the effects of such systematic variations of the counting limit while counting stars on a single plate each cluster was divided into four quadrants and the quarter-rings thus formed were then counted in what was effectively a random order.

The basic data on each cluster were obtained by counting stars down to the plate limit on plates with different limiting magnitudes. In a number of cases these data were supplemented by counting only those stars brighter than a certain star of known magnitude, which was well above the plate limit. The latter data are considered to be of somewhat lower accuracy than the counts down to the plate limit.

The Number of Cluster Stars

To estimate the surface density of background stars, the area which was counted in each case extended well beyond the boundary of the cluster. A "rule of thumb" was to choose the background area roughly equal to the cluster area, but this precept was not followed rigidly.

Suppose that the adopted background area, A_b, contains N_b stars, then the density of background stars, σ_b, is

$$\sigma_b = \frac{N_b}{A_b} \tag{1}$$

Let there be $N(r_n)$ stars in the nth ring within the cluster, then the number of cluster stars within the ring is

$$N_c(r_n) = N(r_n) - A(n)\,\sigma_b \tag{2}$$

where $A\ (n)$ is the area of the nth ring.

Mean errors were associated with each determination of the number of cluster stars. These errors were obtained in the following way:
Let

ϵ_c = mean error of the number of cluster stars

ϵ_1 = mean error of the number of background stars within the area of the cluster, due to the uncertainty in the surface density of background stars, σ_b

ϵ_2 = error due to the statistical fluctuations of the number of background stars, themselves, within the cluster
then

$$\epsilon_c^2 = \epsilon_1^2 + \epsilon_2^2 \tag{3}$$

in which

$$\epsilon_1^2 = N_b \frac{A_c^2}{A_b^2} \quad \text{and} \quad \epsilon_2^2 = N_b \frac{A_c}{A_b}$$

where A_b is the background area and A_c is the cluster area.
It should be emphasized that these errors do not take into account the uncertainties in the adopted limiting magnitudes or the uncertainties which might be introduced by irregular absorption over the background or cluster areas. Most of the clusters which will subsequently be discussed were selected for observation because they appeared projected on a relatively smooth field of background stars.

Determination of the Limiting Magnitudes

(a) Standard Sequences

Photoelectric sequences and (or) photographic transfers were used to establish a standard sequence in or near each cluster. The photographic magnitudes of the sequence stars were determined with the Eichner photometer of the California Institute of Technology. All magnitudes were transformed to the P system by means of the relation (Allen 1955).

$$P - V = 1.10\,(B - V) - 0.18 \tag{4}$$

Details on individual magnitude sequences are given below:

NGC 188: A photoelectric magnitude sequence to magnitude 17.2 was kindly supplied by Dr. Sandage. As NGC 188 lies less than 5° from the pole two transfer plates were taken, with both the cluster and the North Polar Sequence appearing on the same 14 × 14 inch plate. These transfers were used to set up a sequence in the cluster that included fainter stars than those in the photoelectrically obtained sequence. No significant deviations were found in the magnitude range where the two sequences overlap.

NGC 436, NGC 457, NGC 559, NGC 581, NGC 663, Trumpler 1: A photoelectric sequence by Pesch (1959) down to magnitude 14.6 was used. The sequence was extended by means of a photographic transfer to SA 51 in which Dr. Baum had established a photoelectric sequence which he kindly made available to us.

NGC 1907, NGC 1960: A magnitude sequence was set up by means of two photographic transfers to SA 51. No systematic differences between this sequence and sequences set up by Johnson and Morgan (1953) to $m_{pg} = 12.7$ and Cuffey (1937a) to $m_{pg} = 16.6$ were found.

NGC 2099: The magnitude sequence depends on one photographic transfer to SA 51.

NGC 2141, NGC 2194: The magnitude sequence depends on two photographic transfers to SA 51. Comparison of our sequence with one set up by Cuffey (1943) in NGC 2194 indicates a systematic difference in the sense m (Cuffey) $- m$ (adopted) $= 0.08$. Cuffey's sequence extends to magnitude 16.6.

NGC 2158: A photoelectric sequence in this cluster down to magnitude 20.0 was kindly made available to us by Dr. Arp.

NGC 2362: A photoelectric sequence down to magnitude 15.1 has been obtained in this cluster by Johnson and Morgan (1953). The sequence was extended to fainter magnitudes by means of two transfers to SA 57 in which a photoelectric sequence had been set up by Baum. The photographic transfers to this cluster are rather unsatisfactory since they were affected by fogging due to the lights of San Diego.

NGC 2477: A sequence by Miss Sawyer (1930), which is probably of rather low accuracy, was used.

NGC 2506, NGC 2539: The adopted magnitude sequences depend on two photographic transfers to SA 57.

NGC 2682: A photoelectric sequence down to magnitude 17.0 by Johnson and Sandage (1955) was extended to fainter magnitudes by means of two photographic transfers to SA 51. The transfer magnitudes were reduced by 0.2 magnitudes to bring them into agreement with the photoelectric sequence.

NGC 7789: A photoelectric sequence (Burbidge and Sandage 1958) down to magnitude 17.3 was kindly supplied by Dr. Sandage. This sequence was extended by means of two transfers to SA 68. The transfer magnitudes were shifted by 0.78 magnitudes to bring them into agreement with the photoelectric data. This large zero point error is probably due to the fact that the cluster was rather far west at the time of observation so that the plates may have been affected by twilight.

IC 361: The adopted magnitude sequence depends on two photographic transfers to SA 57.

In some cases the number of standard stars in a given magnitude interval was rather small. In such cases the magnitudes of additional stars were interpolated by measuring image diameters.

(*b*) *Determination of the plate limits*

The provisional limiting magnitude of each plate was determined from the standard sequence on that plate. Let m_i and m_j be the magnitudes of two adjacent stars of this sequence. If star i was visible but star j was not, then $\frac{1}{2}(m_i + m_j)$ was adopted as the provisional limiting magnitude of the plate. Sometimes the appearance of the images suggested that this limiting magnitude was too bright, or perhaps, too faint and the simple average, accordingly, was reduced or increased slightly. In the case of transfer plates it was assumed that the limiting magnitude in the selected area was equal to that in the cluster.

The limiting magnitudes obtained in this manner are unsatisfactory on two counts:

(1) The limiting magnitude is an interpolation between two limits m_i and m_j which in a representative sequence might differ by 0.3 magnitudes.

(2) No account is taken of possible fluctuations in the sensitivity of the photographic emulsion as a function of position on the plate. Clearly such variations might affect the visibility or invisibility of a certain sequence star.

The provisional limiting magnitudes were therefore adjusted by requiring them to fulfil the condition that the background count, $N_b(m)$ must be a smoothly increasing function of the limiting magnitude. Experience shows that the effective counting limit lies somewhat above the actual plate limit. From a comparison of the luminosity function of the inner region of M67 derived in this paper, with that obtained by Johnson and Sandage (1955) it was estimated that the effective counting limit is 0.5 magnitudes brighter than the actual plate limit. This correction was applied to the limiting magnitude of all counts down to the plate limit. The magnitudes in Tables I and II (see p. 220 to p. 235) therefore refer to the actual limiting magnitude of the counts and not to the plate limit itself.

TABLE III
BASIC DATA ON CLUSTERS

Cluster	$m-M_{pg}$	$m-M_o$	Distance	Age
NGC 188	10.5	10.5	1250 pc	old
NGC 436	13.7:	11.7:	2200:	young
NGC 457	14.3	12.3	2900	young
NGC 559	14.5:	11.7:	2200:	young
NGC 581 (M103)	13.9	11.9	2400	young
NGC 663	15.3	12.1	2600	young
NGC 1907	13.1::	11.1::	1650::	young
NGC 1960 (M36)	11.5	10.5	1250	young
NGC 2099 (M37)	11.1	10.7	1400	intermediate
NGC 2141	—	—	—	intermediate?
NGC 2158	14.8	13.4	4800	intermediate
NGC 2194	12.9:	10.4:	1200:	intermediate
NGC 2362 (τ CMa)	11.2	10.8	1450	young
NGC 2477	10.5::	—	—	intermediate
NGC 2506	—	—	—	intermediate?
NGC 2539	10.5	9.4	750	intermediate
NGC 2682 (M67)	9.8	9.5	800	old
NGC 7789	12.5	11.4	1850	intermediate
IC 361	—	—	—	intermediate?
Trumpler 1	14.2:	11.7:	2200:	young

NOTES ON TABLE III

NGC 188: Modulus obtained by fitting Sandage's provisional main sequence to the zero-age main sequence. Zero reddening was assumed.

NGC 436: True distance modulus taken from Bodén (1951). Absorption assumed to be same as that measured in the nearby cluster NGC 457 by Pesch (1959).

NGC 457: Data from Pesch (1959).

NGC 559: Data derived from Hiltner's (1956) observations of H.D. 8768 and H.D. 9105 using Johnson's (1959) intrinsic colours.

NGC 581: From Krušpán (1959). Hiltner's (1956) data on B.D. +59°273 confirm Krušpán's estimate of the reddening.

NGC 663: Data derived from Hiltner's (1956) observations of B.D. +60°331, 333, 339, 343 using Johnson's (1959) intrinsic colours.

NGC 1907: Distance and reddening were obtained under the assumption that the cluster is physically associated with nearby OB stars. The data for these OB stars were taken from Hiltner (1956).

NGC 1960: Data from Johnson (1957).

NGC 2099: Apparent modulus obtained by assuming the red giants in this cluster (Lindblad 1954) to have the same M_{pg} as those in the Hyades and Praesepe.

NGC 2158: Modulus obtained by fitting the colour-magnitude diagram given by Cuffey (1937b) to that of NGC 7789. The cluster-reddening was estimated by comparing provisional photoelectric magnitudes and colours obtained by Arp for some stars on the red giant branch with those obtained by Burbidge and Sandage (1958) in NGC 7789.

NGC 2194: Data from Cuffey (1943).

NGC 2362: Data from Johnson (1957).

NGC 2477: Measurements of the diameters of stellar images on red and blue plates indicate that the cluster colour-magnitude diagram is possibly intermediate between those of NGC 752 and M67. The cluster main sequence terminates at about $m_{pg} = 13.0$. Assuming this to correspond to $M_{pg} = +2.5$ one obtains $m - M_{pg} = 10.5$.

NGC 2539: Modulus obtained by comparing the cluster red giants (Zug 1933) with those in the Hyades and Praesepe. Absorption estimated by assuming $A_{pg} =$ 0.24 cosec b.

NGC 2682: Data from Johnson and Sandage (1955).

NGC 7789: Data from Burbidge and Sandage (1958).

Trumpler 1: Modulus from Krušpán (1959). Hiltner's (1956) colour excess for B.D. +60°274 is consistent with the absorption used by Krušpán.

THE LUMINOSITY FUNCTIONS OF CLUSTERS

(1) Old Galactic Clusters: NGC 188, NGC 2682 (M67)

NGC 188 and M67 are the two oldest known galactic clusters. Both clusters are located at intermediate galactic latitudes and are therefore particularly well suited for a determination of their luminosity functions. M67 appears projected on a very smooth stellar background.

Some faint emission and reflection nebulosity is visible in the vicinity of NGC 188 and star counts indicate some irregularities in the stellar background. As a result the luminosity function of NGC 188 is probably less accurate than that of M67. The luminosity functions of NGC 188 and M67 are shown on pages 236 and 237 respectively. Comparison of these two figures shows that the luminosity functions of both clusters exhibit a number of points of similarity. The integral luminosity functions of NGC 188 and M67 show a sudden increase in slope at $m_{pg} \simeq 15.6$ $(M_{pg} \simeq +5.1)$ and $m_{pg} \simeq 13.3$ $(M_{pg} \simeq +3.5)$ respectively corresponding to the termination points of the cluster main sequences. In both clusters the integral luminosity function has the largest slope (maximum of the differential luminosity function) less than one magnitude below the termination point of the main sequence. Below this maximum the luminosity functions decrease continuously down to the limits of observation. Comparison of the luminosity functions for the entire cluster with those for the inner region of each cluster shows that the brightest and hence most massive stars are more strongly concentrated towards the cluster nuclei than are the faintest least massive stars. Such an effect would be expected on dynamical grounds since both clusters are considerably older than their respective times of relaxation.

Table IV gives for both clusters the distance from the galactic plane, Z, the radius containing half of the cluster mass in projection, $r_{\frac{1}{2}}$, the largest distance to which the cluster could be traced, r_m, the extrapolated total cluster mass, $\mathfrak{M}$, the extrapolated total number of cluster stars, N, and the cluster relaxation time, τ, computed by means of an equation recently given by King (1959).

TABLE IV

DATA ON NGC 188 AND M67

Cluster	Z	$r_{\frac{1}{2}}$	r_m	$\mathfrak{M}$	N	τ
NGC 188	+ 500 pc.	6.5′ = 2.4 pc.	20′ = 7.2 pc.	$900\mathfrak{M}_\odot$	1200:	1.2×10^8 y.
M67	+ 450	9.4 = 2.2	28 = 6.5	800	1000:	1.0×10^8

The mass-luminosity law tabulated by Schmidt (1959) was adopted to determine the total cluster mass. Stars which have evolved from the main sequence were assigned masses of 1.0 and 1.2 $\mathfrak{M}_\odot$ respectively in NGC 188 and M67. The mass in the form of white dwarfs was assumed to be $50\mathfrak{M}_\odot$ in NGC 188 and $40\mathfrak{M}_\odot$ in M67. The extrapolated total number of cluster stars, N, is considerably less accurate than the extrapolated total cluster mass $\mathfrak{M}$.

(2) Galactic Clusters of Intermediate Age: NGC 2099 (M37), NGC 2141, NGC 2158, NGC 2194, NGC 2477, NGC 2506, NGC 2539, NGC 7789, IC 361.

The luminosity functions of clusters of intermediate age (pages 238 to 246) show a number of interesting differences. Some of these differences are due to evolutionary effects, i.e. differences in the shapes of the red giant branches of the cluster colour-magnitude diagrams. In other clusters the differences are due to genuine differences in the cluster main sequence luminosity functions.

In the clusters NGC 2158 (p. 240) and NGC 7789 (p. 245) the slope of the integrated luminosity functions changes abruptly at $m_{pg} \simeq$ 17.0 ($M_{pg} \simeq + 2.2$) and $m_{pg} \simeq 14.0$ ($M_{pg} \simeq + 1.5$) respectively. This change in slope corresponds to the termination point of the cluster main sequence and to a concentration of red giants at the beginning of the cluster giant branch. The same explanation may also account for the sudden change in slope near $m_{pg} \simeq 17.7$ in the rich cluster NGC 2141 (p. 239), for which the distance modulus is unfortunately unknown. A similar explanation may account for the change in slope of the integral luminosity function of NGC 2506 (p. 243) near $m_{pg} \simeq$ 15.5 for which the distance modulus is also unknown.

The figure on p. 238 shows that the main sequence luminosity function of NGC 2099 (M37) has a flat maximum between the termination point of the cluster main sequence near $M_{pg} = 0$ and $M_{pg} = +4$. For fainter stars the luminosity function appears to decrease gradually. The main sequence luminosity functions of NGC 2477 (p. 242), NGC 2506 (p. 243) and NGC 2539 (p. 244), also seem to decrease slightly towards fainter magnitudes. The main sequence luminosity function of NGC 7789 (p. 245) appears to remain approximately constant over the range $+2.5 < M_{pg} < +5.5$. On the other hand the luminosity function of NGC 2194 (p. 241) seems to increase down to the limit of observation at $M_{pg} = +6$.

The data gave some indication that the brightest stars in NGC 2099 (M37), NGC 2194 and IC 361 are more concentrated towards the cluster nucleus than are the fainter stars.

(3) Young Galactic Clusters: NGC 436, NGC 457, NGC 559, NGC 581 (M103), NGC 663, NGC 1907, NGC 1960 (M36), NGC 2362 (τ CMa), Trumpler 1.

Young galactic clusters, which have only recently been formed from the interstellar gas, are usually located at low galactic latitudes. They, therefore, appear projected on a rich stellar background, which, due to the effects of absorbing interstellar clouds, is often quite irregular. As a result the luminosity functions of young galactic clusters are less reliable than those for the clusters of intermediate age, which have been discussed previously. Only in the case of the clusters NGC 436, NGC 457 and NGC 2362 was the background sufficiently homogeneous to determine the luminosity function in the usual manner.

For the other clusters it could, however, be assumed that the background was reasonably uniform over the two innermost rings. For these clusters only $f\phi(M)$ could be determined, in which f is an unknown constant which is smaller than one and $\phi(M)$ is the luminosity function of the entire cluster.

Let $N(r_n,m)$ be the total number of stars brighter than m in ring n and let $N_c(r_n,m)$ be the number of cluster stars brighter than m in ring n, then

$$N_c(r_n,m) = N(r_n,m) - \sigma_b(m)\ A(n) \tag{5}$$

in which $\sigma_b(m)$ is the surface density of background stars brighter than m and $A(n)$ is the area of ring n. Since we are dealing with very young clusters, which have ages smaller than their times of relaxation, it will be assumed that the radial density distribution of cluster stars is identical for *all* magnitudes. Equation (5) may then be written

$$K(n)\ N_c(m) = N(r_n,m) - \sigma_b(m)\ A(n) \tag{6}$$

in which $K(n)$ is the fraction of all cluster stars $N_c(m)$ in ring n. From equation (5) for rings 1 and 2 one obtains

$$f\,N_c(m) = \left[K(1) - \frac{K(2)}{3}\right]N_c(m) = N(1,m) - \frac{N(2,m)}{3} \tag{7}$$

This equation was used to determine the function $f\phi(M)$ for those clusters in which the absorption was judged to be relatively homogeneous over the nuclear region of the cluster.

The luminosity functions of the nine young clusters which were studied in the present investigation are shown on pages 247 to 250. The data indicate that the luminosity functions of young clusters differ from cluster to cluster. In the majority of the clusters the luminosity function appears to increase rapidly and then remains constant down to the limit of the observations. On the other hand the figures on p. 250 indicate that the clusters NGC 1907, NGC 1960 (M36) and NGC 2362 (τ CMa) appear to contain few if any intrinsically faint stars.

Star counts were made on the red prints of the Palomar Sky Survey in NGC 1907 and NGC 1960 to check the possibility that the apparent absence of faint cluster stars might be due to some peculiarity of the absorption in or near the nuclei of these clusters. Such absorption would of course be less effective in the red than in the blue. The results of the counts on the Sky Survey red prints are shown as open circles on p. 250 and seem to agree with the results obtained from the blue plates. Due to the fact that interstellar absorption is smaller in the red than in the blue, and because the faintest cluster stars are intrinsically red, the counts on the red prints should reach even fainter cluster stars than those recorded on the blue plates. It is therefore concluded that the absence of intrinsically faint stars in NGC 1907 and NGC 1960 (M36) is probably real. The possibility that the least massive stars in such very young clusters are still non-luminous, should of course, be kept in mind.

It is of some interest to note that if ϕ Cas is a member of NGC 457 (Pesch 1959), then the cluster contains stars with a brightness range of at least 15 magnitudes. On the other hand the main sequences of NGC 1907 and NGC 1960 (M36) only appear to be populated over a range of about 7 magnitudes.

The Radial Density Distribution of Cluster Stars

From the counts of stars in rings centred on the cluster nucleus the radial density distribution of cluster stars could be determined for the majority of the clusters contained in the present programme. The results are shown in figure 2, in which the fraction of all cluster stars $F(r/r_{\frac{1}{2}}^*)$ within radius r is plotted as a function of $r/r_{\frac{1}{2}}^*$ in which $r_{\frac{1}{2}}^*$ is the radius containing half of the cluster stars in projection. A cluster in which cluster stars could be traced out to a distance of n rings is represented in the figure by n points. The figure shows that the radial density distributions of all clusters which have been investigated are essentially similar. The scatter of the points for the outer regions of clusters may be largely due to the uncertainties inherent in the observations. The data for the high latitude clusters NGC 188 and M67 and the very rich cluster NGC 7789, which are believed to be more accurate than those for the other clusters, are given in Table V (the points for these clusters are shown as large dots in figure 2).

TABLE V

FRACTION OF ALL CLUSTER STARS $F(r/r_{\frac{1}{2}}^*)$ WITHIN RADIUS $r/r_{\frac{1}{2}}^*$

					NGC 188						
$r/r_{\frac{1}{2}}^*$	0.00	0.44	0.87	1.30	1.74	2.17	2.61	3.04			
F	0.00	0.17	0.43	0.65	0.77	0.86	0.95	1.00			
					NGC 2682 (M67)						
$r/r_{\frac{1}{2}}^*$	0.00	0.29	0.59	0.88	1.18	1.47	1.76	2.06	2.35	2.65	2.94
F	0.00	0.10	0.28	0.43	0.58	0.71	0.80	0.86	0.93	0.96	1.00
					NGC 7789						
$r/r_{\frac{1}{2}}^*$	0.00	0.34	0.69	1.03	1.38	1.72	2.07	2.41	2.76	3.10	
F	0.00	0.11	0.34	0.51	0.68	0.81	0.90	0.94	0.98	1.00	

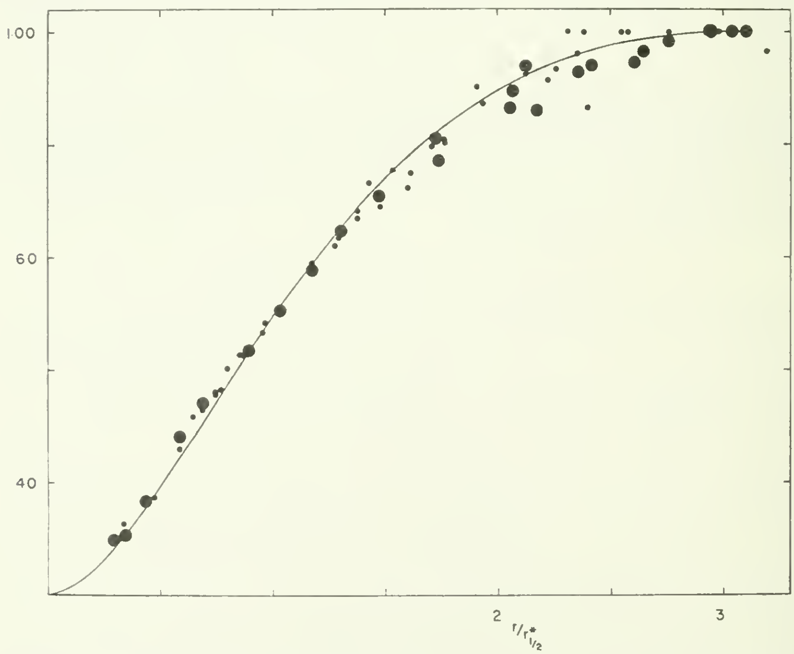


FIG. 2—Fraction of the total number of cluster stars $F(r/r_{\frac{1}{2}}^*)$ within a distance $r/r_{\frac{1}{2}}^*$ of the cluster centre. ($r_{\frac{1}{2}}^*$ is the radius containing half of the cluster stars in projection.) The curve shows $F(r/r_{\frac{1}{2}}^*)$ for an isothermal cluster.

In figure 2 a smooth curve shows $F(r/r_{\frac{1}{2}}^*)$ for an isothermal cluster with a cutoff at $\xi = 10$, which has been tabulated by Chandrasekhar (1942). The scale factor for the isothermal distribution was chosen such that $F = 0.5$ for $r = r_{\frac{1}{2}}^*$. Comparison of the observed points, with the curve representing an isothermal cluster, shows systematic deviations which are probably significant. For $r/r_{\frac{1}{2}}^* < 0.5$ the observed points lie above the isothermal curve and for $r/r_{\frac{1}{2}}^* > 0.5$ the observed points fall predominantly below it. The observations may be represented remarkably well by a stellar surface density, σ, of the following form

$$\frac{\sigma(r)}{\sigma(o)} = e^{-1.68r/r_{\frac{1}{2}}^*} \tag{8}$$

The data on the radii of the clusters contained in the present programme are given in Table VI.

TABLE VI

CLUSTER RADII CONTAINING HALF OF THE CLUSTER STARS IN PROJECTION

	$r_{\frac{1}{2}}^*$		D		$r_{\frac{1}{2}}^*$		D
NGC 188	8′.5	= 2.4 pc.	1250 pc.	NGC 2362	1′.6:	= 0.7:pc.	1450 pc.
NGC 436	1′.8:	= 1.2:pc.	2200:pc.	NGC 2477	6′.0	—	—
NGC 457	3′.8	= 3.2 pc.	2900 pc.	NGC 2506	4′.8	—	—
NGC 2099	8′.8	= 3.6 pc.	1400 pc.	NGC 2539	6′.7	= 1.5 pc.	750 pc.
NGC 2141	4′.1	—	—	NGC 2682	9′.7	= 2.3 pc.	800 pc.
NGC 2158	3′.6	= 5.0 pc.	4800 pc.	NGC 7789	8′.2	= 4.4 pc.	1850 pc.
NGC 2194	3′.7	= 1.3:pc.	1200:pc.	IC 361	3′.8	—	—

The data in the table may indicate a loose correlation between the radius containing half the total number of cluster stars and the stellar content of the clusters. NGC 2158 and NGC 7789, which are extremely rich, are seen to have larger than average radii.

DISCUSSION OF RESULTS

Probably the most striking feature revealed by the luminosity functions shown on pages 236 to 250 is that significant differences exist between the luminosity functions of individual galactic clusters. Some of these differences may be explained in terms of the effects of stellar evolution on the positions of cluster stars in the Hertzsprung-Russell diagram. However, evolution of individual stars cannot account for the differences which are observed among the luminosity functions of unevolved main sequence cluster stars. The data on the luminosity functions of those clusters for which the observations extend below $M_{pg} = +5$ are summarized in Table VII. The data for the Hyades, Pleiades and Praesepe were taken from Sandage (1957).

TABLE VII

THE FAINT ENDS OF CLUSTER LUMINOSITY FUNCTIONS

Cluster	Limiting M_{pg}	$\phi(M_{pg})$
NGC 188	+10	Decreasing
NGC 436	+ 6	Constant?
NGC 457	+ 6	Constant?
NGC 559	+ 6	Constant?
NGC 581 (M103)	+ 6	Decreasing slightly?
NGC 663	+ 5	Decreasing slightly?
NGC 1907	+ 7	Decreasing
NGC 1960 (M36)	+ 9	Decreasing
NGC 2099 (M37)	+ 8	Decreasing slightly
NGC 2194	+ 6	Increasing
NGC 2362 (τ CMa)	+ 9	Decreasing
NGC 2539	+ 8	Decreasing slightly
NGC 2682 (M67)	+11	Decreasing
NGC 7789	+ 6	Constant
Trumpler 1	+ 6	Constant?
Hyades	+ 7	Constant
Pleiades	+10	Decreasing slightly
Praesepe	+ 7	Constant

Table VII shows that, with only one exception, the faint ends of the luminosity functions of galactic clusters either decrease or remain constant. This behaviour is in sharp contrast to that of the van Rhijn-Luyten luminosity function for field stars in the vicinity of the sun. Recent computations by Schmidt (1959) show that $\phi(M_{pg})$ for field stars begins to increase sharply at $M_{pg} = +5$. The present observations show that such an increase does not, in general, occur in the luminosity functions of galactic clusters.

In the case of very old clusters like NGC 188 and M67 it might be assumed that the difference between the cluster luminosity functions and the van Rhijn-Luyten luminosity function is due to the escape of faint cluster stars (van den Bergh 1957). However, the relaxation times of these clusters (see Table IV) are so long that it now appears unlikely that the entire discrepancy could be accounted for in this way. The fact that faint stars appear to be almost absent in such young objects as NGC 1907, M36 and the τ Canis Majoris cluster could conceivably be accounted for by assuming that such faint stars have not yet contracted to a position near the main sequence. However, this appears unlikely in the light of Walker's (1956) observations of the extremely young cluster NGC 2264, which show that stars as faint as $M_{pg} = +8$ occur in that cluster. In any case neither of the two special hypotheses outlined above could account for the differences between the van Rhijn-Luyten luminosity function and the luminosity functions of galactic clusters of intermediate age.

The differences between the luminosity functions of galactic clusters on the one hand and the luminosity function of field stars on the other may be accounted for in a number of ways. It may be assumed that:

(1) There now exists a universal cluster luminosity function which is identical to the luminosity function of star creation during the last few million years and this luminosity function differs from the initial luminosity function of star creation in the galaxy.

(2) The luminosity function of galactic star clusters is not representative of the luminosity function of star creation. This presumably implies that the conditions under which star clusters are created are not representative of the conditions under which "average" stars in the galaxy were formed.

For a number of reasons, the second hypothesis appears more attractive than the first. If the first hypothesis were correct then, to account for the present luminosity function of field stars, one would have to assume that the luminosity function of star creation in the galaxy initially contained a much larger fraction of faint stars than it does now. This is equivalent to saying that the initial luminosity function of star creation must have been deficient in bright stars. According to current views on stellar evolution, the ejection of heavy elements, formed by nucleogenesis in bright stars, enriches the heavy element concentration in the interstellar gas. It is, therefore, difficult to see how the presumably rapid increase in the heavy element abundance during the first phase of the evolution of the galaxy could be understood if the luminosity function of star creation were initially deficient in massive stars.

The striking differences between the luminosity functions of individual galactic clusters makes it difficult to believe in the universality of the luminosity function of star creation. It would appear to be more reasonable to assume that the differences between individual star clusters and also between star clusters on the one hand and field stars on the other are due to different physical conditions in the regions of star creation. Although our understanding of the processes by which stars are created from the interstellar gas is still very fragmentary, it appears likely that the resulting spectrum of stellar masses will depend to some extent on the prevailing gas density, temperature and turbulent velocity and perhaps also on the prevailing strength and configuration of the magnetic field.

The conclusion that the luminosity function with which stars are created depends on the physical conditions prevailing in the region of star formation implies that it is not possible to obtain a significant determination of the change in the rate of star formation with time by comparing the present main sequence luminosity function of bright field stars with the bright ends of cluster luminosity functions. Assuming the dependence of the rate of star formation, $f(t)$, on the gas density ρ, to be given by

$$f(t) \sim \rho^n \tag{9}$$

Schmidt (1959) obtains $n = 1$ to 2 from a comparison of the main sequence luminosity function of bright field stars with a "mean" luminosity function of bright stars in young clusters. On the other hand he finds that a comparison of the distribution of young stars and interstellar gas perpendicular to the galactic plane yields $n = 2$ to 3. The present investigation suggests that this discrepancy may be due to the fact that it is not legitimate to assume that the luminosity functions of galactic clusters are identical to the general luminosity function of star formation.

(Concluded on page 251)

TABLES AND FIGURES

Information concerning the arrangement of the tabular material and figures is given below.

Table I - Star Counts

The table contains the actual number of stars counted per ring down to each limiting magnitude. Limiting magnitudes marked by an asterisk refer to counts of stars brighter than a star of that magnitude. Limiting magnitudes not so marked refer to counts to the plate limit. Uncertain limiting magnitudes are followed by a colon. Limiting magnitudes followed by the letters B or R refer to counts on the blue or red prints of the Palomar Sky Survey. A vertical line in the tables indicates the adopted boundary between the cluster and background areas. In NGC 2158 and NGC 7789 numbers in parenthesis are counts corrected for overlapping images in the crowded cluster nuclei. In NGC 2158 numbers preceded by a minus sign give the number of background stars in the quadrant containing the nearby cluster M35. These were subtracted from the total number of stars in each ring to give the adopted background.

Table II - Integral Luminosity Functions

The table gives the total number of cluster stars N(m) down to each limiting magnitude as determined from the star counts in Table I. For most clusters the data are given separately for the inner region of the cluster, in which the cluster luminosity function is less affected by uncertainties in the adopted background level, than is the luminosity function of the entire cluster. For a number of young clusters only f N(m) is given in which f is an unknown constant which is smaller than one. In the case of NGC 2362 the inner half ring was excluded because the data are affected by the bright star τ CMa which is in the centre of the cluster.

Figures

The following figures give the integral luminosity functions (below) and differential luminosity functions (above) for the clusters contained in the present programme. The data for the inner cluster region are represented by the lower curve (scale on right) and solid histogram. The data for the entire cluster are given by the upper curve (scale on left) and the open histogram. Data obtained from the red prints of the Palomar Sky Survey are shown as open circles.

TABLE I - STAR COUNTS

NGC 188

Ring / m_{pg}	1	2	3	4	5	6	7	8	9	10
9.90*	0	0	1	1	1	1	0	2	1	0
12.02*	0	1	1	4	3	6	3	4	2	6
13.15*	2	7	5	12	2	9	4	8	5	15
13.40	3	4	6	8	5	11	5	12	9	16
14.17*	7	22	12	19	10	20	20	20	24	31
14.71*	13	26	19	24	19	39	32	45	43	47
15.21*	21	46	30	29	22	46	42	48	47	59
15.59*	28	63	40	41	27	53	50	64	59	71
16.52*	75	171	124	110	81	111	93	135	116	148
17.00	86	159	138	129	104	135	131	161	160	180
17.23*	98	193	145	140	124	150	148	176	179	199
17.60	106	212	180	176	156	198	200	219	226	252
17.65	109	206	183	179	155	189	186	218	228	269
17.80*:	120	234	202	185	187	227	226	236	268	315
18.15:	114	226	213	190	196	225	236	250	284	333
18.40:	122	238	221	219	206	255	256	283	316	376
20.00:B	174	314	336	341	370	444	465	506	582	616
R	179	330	390	365	416	479	545	577	663	668

NGC 436

Ring / m_{pg}	1	2	3	4	5
9.68*	0	0	0	0	0
10.35*	0	1	0	0	2

NGC 457

Ring / m_{pg}	1	2	3	4	5	6	7
5.77*	0	1	0	0	0	0	0
7.53*	0	2	0	0	0	0	0

11.82*	5	1	0	6	2
13.14*	13	2	2	11	7
14.50	19	8	15	22	20
14.90	34	17	26	41	32
15.45	41	23	34	54	51
16:00:	48	33	44	68	74
16.25	51	43	52	91	104
16.45	60	58	61	90	116
20.30:B	278	410	677	933	1201
R	277	493	739	932	1151

9.68*	1	5	1	1	0	0	1
10.35*	4	7	5	1	2	0	2
11.82*	12	18	9	3	4	0	4
13.14*	21	26	14	7	6	1	8
14.50	43	53	25	30	36	29	48
14.90	45	65	26	41	42	39	55
15.45	53	81	41	55	53	62	76
16.25	71	112	75	99	89	109	128
16.45	70	117	92	104	97	123	149
20.30:B	260	476	659	831	1084	1231	1437

	NGC 559		NGC 581		NGC 663		Tr 1	
Ring	1	2	1	2	1	2	1	2
m_{pg}								
9.68*	0	0	1	1	0	1	0	0
10.35*	0	0	2	1	0	5	0	0
11.82*	0	2	13	3	5	14	6	0
13.14*	3	3	23	8	20	26	8	2
14.50	11	3	46	27	38	41	30	17
14.90	19	6	52	38	45	57	34	26
15.45	29	21	52	54	55	97	45	36
16.00:	38	28	58	74	61	106	48	40
16.25	51	40	69	89	69	128	61	47
16.45	59	53	66	100	75	135	63	58
16.85*:	85	115	83	166	82	159	78	109
18.60:	-	-	125	277	133	264	116	171
19.30:	-	-	195	432	154	349	156	326
20.30:B	259	426	280	675	227	456	242	451
R	318	651	282	697	250	610	297	621

TABLE I (continued)

Ring / m_{pg}	NGC 1907 1	NGC 1907 2	NGC 1960 1	NGC 1960 2
7.53*	0	0	0	0
9.08*	0	0	6	2
9.58*	0	0	7	3
10.51*	2	0	9	6
11.55	4	2	13	9
12.25	5	3	17	13
13.70	16	13	28	31
14.35	35	27	39	44
15.00	50	47	43	53
15.25	49	54	45	63
15.60	66	72	48	67
16.20	75	92	50	76
17.50	95	140	61	107
18.20	105	159	67	135
18.40	96	183	-	-
18.40	94	171	-	-
18.70	108	194	66	149
19.10	116	232	78	169
20.50:B	-	-	147	377
20.60:B	182	368	-	-
R	189	413	183	477

NGC 2099 (M37)

Ring / m_{pg}	1	2	3	4	5	6	7	8	9	10	11
10.68*	3	0	1	0	0	1	1	1	3	8	1
11.72*	37	29	32	17	11	5	6	14	8	18	7

12.78*	79	73	66	41	34	19	17	27	23	31	19
13.60	97	118	87	59	63	58	39	69	58	74	52
13.65	92	107	95	63	68	59	45	75	65	82	64
14.00	118	132	123	88	108	87	71	105	90	118	104
14.15	108	137	119	97	112	96	90	106	120	133	116
14.50	124	153	146	130	139	125	125	149	168	160	176
14.65	127	161	158	138	158	146	144	167	186	181	191
15.55	145	216	229	199	231	231	266	279	297	326	344
17.40	182	331	374	418	485	537	624	666	753	849	886
17.95	192	374	432	507	585	711	762	875	909	1040	1148
18.20	202	368	455	582	675	771	877	958	1072	1180	1186
18.60	210	393	529	615	749	847	959	1074	1172	1353	1428
19.35	222	487	605	792	890	1117	1173	1379	1536	1604	1677

NGC 2141

Ring / m_{pg}	1	2	3	4	5	6	7
12.35*	0	4	2	4	5	7	6
13.76*	3	13	18	19	27	23	27
14.89*	6	16	24	24	44	32	44
16.15	36	33	55	68	87	89	121
16.75	45	56	83	96	135	121	172
17.10	59	70	95	123	160	156	202
17.65	75	121	128	173	222	229	301
17.85	100	143	160	203	249	282	321
18.20	138	209	216	278	289	351	434
18.35	153	240	252	322	340	416	474
18.40	174	246	268	323	342	439	500
18.95	206	345	360	463	524	630	705
19.30	240	417	453	586	653	762	882
19.55:B	380	517	568	655	719	854	1059

TABLE I (continued)

NGC 2158

Ring / m_{pg}	1	2	3	4	5	6	7
10.69*	1	1	4	3	0	4	6
						-1	-4
12.85	8	8	16	15	21	24	39
						-8	-22
13.65	13	15	23	21	38	40	64
						-12	-30
14.00	9	20	30	27	51	53	81
						-18	-39
14.35	17	26	36	39	76	65	92
						-19	-37
15.35	28	33	67	71	113	113	150
						-30	-55
16.00	68	76	106	106	160	180	216
						-59	-85
16.70	92	109	145	152	213	244	317
						-80	-123
16.90	100	125	158	167	231	271	342
						-89	-124
18.00	281	262	270	302	381	453	597
	(286)	(264)	(271)	(303)		-156	-193
18.50	331	343	346	403	476	621	719
	(338)	(345)	(348)	(405)		-219	-221
19.00	474	493	442	525	618	773	946
	(495)	(500)	(447)	(529)		-268	-278
19.25	442	563	520	632	699	903	1024
	(469)	(577)	(528)	(640)		-286	-324

NGC 2194

Ring / m_{pg}	1	2	3	4	5
10.72*	1	0	1	1	2
11.45*	0	1	2	2	2
11.75	12	7	10	10	16
11.80	14	9	16	8	19
12.35*	3	6	14	18	16
13.76*	24	20	31	40	35
14.89*	47	35	40	55	47
16.15	69	69	73	72	79
16.75	97	97	102	101	120
17.10	95	115	114	126	150
17.65	119	148	163	184	206
17.85	143	185	190	201	235
17.90	149	168	187	205	243
18.20	171	214	238	239	290
18.25	156	208	238	248	293
18.35	178	218	240	271	313
18.40	178	234	257	278	323
18.65	179	277	292	317	372
18.75	188	290	313	347	404
18.95	209	342	345	368	443
19.30	250	406	442	472	561
19.55:B	274	412	494	506	628

NGC 2362 (τ CMa)

Ring / m_{pg}	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	3
6.63*	1	0	0	0	1
7.61*	1	2	0	0	3

TABLE I (continued)

NGC 2362 (τ CMa) (continued)

Ring / m_{pg}	½	1	1½	2	3
8.83*	3	4	0	0	4
10.17*	9	8	3	0	4
11.21*	15	10	8	2	5
12.25*	15	17	13	1	14
13.40	18	23	16	8	13
14.80	24	27	21	11	27
16.00	25	33	31	22	60
17.50	24	45	59	51	137
18.45	33	60	89	105	262
18.75	30	72	102	110	286
20.00	34	106	169	183	551

NGC 2477

Ring / m_{pg}	1	2	3	4	5	6	7
10.1*	0	0	1	0	0	1	3
11.4*	1	4	5	3	4	6	10
13.1*	19	26	26	7	7	10	20
14.5*	86	121	113	94	85	51	64
15.9*	136	214	232	193	198	164	184
16.8*	169	282	292	263	260	232	294
18.0::	218	466	552	551	567	555	656

NGC 2506

Ring m_{pg}	1	2	3	4	5	6	7
12.15*	3	2	3	1	5	7	8
13.00*	7	5	5	4	9	11	17
13.70*	18	12	14	13	17	24	30
15.05	86	65	51	58	86	92	116
15.50	84	81	66	74	87	101	120
15.85*	51	95	66	98	112	129	100
16.15	157	174	132	156	161	179	198
16.65	200	239	194	197	212	240	263
17.05	231	292	267	282	306	304	358
17.20*	269	401	340	399	463	443	511
18.00	292	460	422	493	547	597	640
18.05*:	302	517	466	552	551	639	740
18.40B	327	485	587	618	634	763	756
18.65	359	584	579	642	666	838	883

NGC 2539

Ring m_{pg}	1	2	3	4	5	6	7	8	9
9.15*	0	0	0	1	0	0	1	0	0
10.90*	2	1	0	5	2	2	2	4	3
12.15*	10	18	10	13	5	5	10	8	6
13.00*	16	27	23	25	16	9	15	11	14
13.70*	21	44	33	42	30	30	38	29	30
15.05	25	53	49	68	58	54	68	57	66
15.50	34	73	71	93	90	91	111	104	129
15.85*	37	85	81	112	119	112	132	124	118
16.15	43	100	101	130	135	149	185	149	216

TABLE I (continued)

NGC 2539 (continued)

Ring / m_{pg}	1	2	3	4	5	6	7	8	9
16.65	50	118	127	178	182	220	244	264	318
17.05	58	137	164	211	230	287	325	333	415
17.20*	69	162	217	262	324	377	441	464	532
18.00	75	187	247	340	400	476	547	603	705
18.05*:	84	192	268	336	409	480	557	578	710
18.65	103	248	343	454	571	669	811	864	1047

NGC 2682 (M67)

Ring / m_{pg}	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
9.78*	0	1	1	0	0	0	1	1	0	0	2	2	2	1	2	2	2	0
10.67*	5	6	4	0	1	0	2	1	3	1	4	3	3	4	3	3	7	1
11.10*	6	7	2	1	1	0	3	1	2	3	3	4	4	3	3	3	6	3
11.51*	8	11	5	3	2	0	3	4	2	3	4	5	3	5	5	4	7	3
11.83*	8	11	5	3	4	1	4	5	3	5	5	8	4	8	7	6	9	4
11.95	11	15	6	4	5	1	4	8	4	4	6	8	5	10	9	5	10	5
12.30*	12	24	8	4	5	3	7	8	4	7	9	11	7	9	11	8	16	8
13.25	20	30	15	7	18	13	10	16	14	23	12	21	18	17	24	18	27	15
13.60	28	44	22	15	25	20	14	18	21	24	24	28	20	24	30	16	26	17
14.30	40	76	38	37	36	30	26	27	33	31	30	34	30	33	37	28	49	26
14.60	42	87	47	57	42	39	32	35	41	34	30	40	33	40	45	37	53	36
15.45	53	89	62	73	59	49	52	45	46	45	47	52	50	55	64	49	75	65
16.30	56	119	74	100	75	75	61	67	67	71	66	74	74	91	94	79	104	84
16.90	65	129	89	108	96	86	76	85	81	83	81	87	95	98	114	98	130	110
17.70	69	130	109	122	111	108	96	99	107	108	118	114	125	127	156	134	162	151

18.55	75	146	130	133	130	124	121	127	130	137	148	156	145	165	204	172	209	208
19.25	78	149	143	165	151	151	149	157	162	177	182	198	183	208	261	241	251	282
19.30	74	158	136	160	142	148	147	157	166	172	181	196	198	211	263	231	276	260
19.40	80	161	145	165	152	152	160	157	179	176	187	192	198	213	270	236	287	270
19.85	79	169	160	173	180	175	172	193	195	214	211	231	228	254	310	294	327	337
20.65B	92	172	179	199	217	212	209	236	236	261	246	280	294	362	406	384	389	424

NGC 7789

Ring m_{pg}	1	2	3	4	5	6	7	8	9	10	11	12
11.07*	1	2	1	5	3	1	6	7	7	5	8	14
12.68*	7	22	12	21	27	26	35	37	25	31	42	49
13.14*	10	24	16	19	26	22	39	36	33	28	38	68
13.88*	17	40	25	40	41	44	36	45	30	45	43	81
14.25	45	86	60	53	62	61	88	71	72	82	92	123
14.75	75	122	103	85	92	106	126	99	109	118	134	165
14.77*	46	92	83	92	91	99	114	114	93	99	104	155
15.09*	99	241	182	218	214	215	256	200	257	227	283	323
15.15	91	186	136	138	144	147	164	159	159	153	196	226
15.45	115	221	183	185	195	171	204	191	190	195	247	272
16.49*	159	346	341	350	391	365	463	433	487	450	515	608
17.26*	197	444	440	528	535	596	639	683	749	821	864	1007
17.60:	225	508	549	651	678	700	795	860	956	1032	1086	1250
	(238)	(526)	(558)	(660)	(685)	(706)	(802)					
18.00:	253	617	677	828	895	943	1072	1131	1274	1372	1511	1690
	(266)	(637)	(687)	(837)	(904)	(950)	(1080)					
18.10:	261	606	671	875	897	994	1068	1254	1326	1443	1581	1805
	(279)	(634)	(686)	(890)	(910)	(1006)	(1081)					
18.20:	272	720	742	941	1001	1105	1183	1355	1473	1683	1745	1943
	(305)	(762)	(763)	(961)	(1019)	(1121)	(1200)					
18.20:	290	686	754	938	1026	1079	1176	1363	1479	1586	1764	1961
	(309)	(717)	(770)	(953)	(1040)	(1091)	(1189)					

TABLE I (concluded)

IC 361

Ring m_{pg}	1	2	3	4	5	6	7
14.60	3	9	8	11	18	28	27
15.50	11	14	17	25	38	52	50
15.80	23	19	25	43	43	60	65
16.15	40	28	26	59	55	83	78
17.10*	65	86	82	84	112	135	162
17.70	180	128	120	154	169	223	221
18.25	153	158	167	201	252	274	340
18.25	136	155	152	200	226	287	338
18.55	162	182	180	235	274	339	403
18.85	180	204	237	287	331	397	480
19.00	215	229	241	304	359	427	526
20.00:B	255	377	412	485	625	713	901
R	317	554	741	845	974	1266	1478

TABLE II - LUMINOSITY FUNCTIONS

NGC 188

m_{pg}	Inner Region Rings 1,2,3	Entire Cluster
9.90*	1 ± 0	1 ± 2
12.02*	0 ± 1	6 ± 5
13.15*	8 ± 1	13 ± 7
13.40	6 ± 2	6 ± 8
14.17*	29 ± 2	40 ± 12
14.71*	34 ± 3	42 ± 16
15.21*	70 ± 3	89 ± 17
15.59*	97 ± 3	116 ± 19
16.52*	300 ± 5	381 ± 27
17.00	295 ± 6	401 ± 31
17.23*	338 ± 6	466 ± 31
17.60	375 ± 7	559 ± 36
17.65	372 ± 7	521 ± 37
17.80*:	412 ± 7	597 ± 39
18.15:	400 ± 7	567 ± 40
18.40:	409 ± 8	581 ± 42
20.00:B	524 ± 10	807 ± 57
R	563 ± 11	873 ± 60

m_{pg}	NGC 436 Inner Region Ring 1	NGC 436 Entire Cluster	NGC 457 Inner Region Rings 1,2	NGC 457 Entire Cluster
5.77*	0 ± 0	0 ± 0	1 ± 0	1 ± 0
7.53*	0 ± 0	0 ± 0	2 ± 0	2 ± 0
9.68*	0 ± 0	0 ± 0	6 ± 0	8 ± 1
10.35*	0 ± 0	1 ± 1	11 ± 1	15 ± 2
11.82*	5 ± 1	5 ± 1	29 ± 1	38 ± 2
13.14*	12 ± 1	11 ± 2	45 ± 1	61 ± 3
14.50	16 ± 2	16 ± 4	82 ± 4	96 ± 9
14.90	19 ± 2	22 ± 5	94 ± 4	111 ± 10
15.45	34 ± 3	37 ± 6	111 ± 5	137 ± 12
16.00:	37 ± 3	43 ± 6	-	-
16.25	39 ± 4	47 ± 7	143 ± 7	199 ± 15
16.45	47 ± 4	67 ± 8	142 ± 7	204 ± 16
20.30:B	144 ± 12	153 ± 25	281 ± 23	406 ± 52
R	143 ± 12	233 ± 25		

m_{pg}	NGC 559 fN(m)	NGC 581 fN(m)	NGC 663 fN(m)	Tr 1 fN(m)
9.68*	0 ± 0	1 ± 0	0 ± 1	0 ± 0
10.35	0 ± 0	2 ± 1	-2 ± 1	0 ± 0
11.82*	-1 ± 1	12 ± 1	0 ± 2	6 ± 0
13.14*	2 ± 1	20 ± 2	11 ± 3	7 ± 1
14.50	10 ± 1	37 ± 3	24 ± 4	24 ± 3
14.90	17 ± 2	39 ± 4	26 ± 5	25 ± 3
15.45	22 ± 3	34 ± 5	23 ± 7	33 ± 4
16.00:	29 ± 4	33 ± 6	26 ± 7	35 ± 4
16.25	38 ± 4	39 ± 6	26 ± 8	45 ± 5

TABLE II (continued)

(cont'd) m_{pg}	NGC 559 fN(m)	NGC 581 fN(m)	NGC 663 fN(m)	Tr 1 fN(m)
16.45	41 ± 5	33 ± 7	30 ± 8	44 ± 5
16.85*:	47 ± 8	28 ± 9	29 ± 8	42 ± 7
18.60:	-	32 ± 11	45 ± 11	59 ± 9
19.30:	-	51 ± 14	38 ± 12	47 ± 12
20.30:B	117 ± 14	55 ± 17	75 ± 14	92 ± 14
R	101 ± 17	50 ± 17	47 ± 16	90 ± 17

m_{pg}	NGC 1907 fN(m)	NGC 1960 fN(m)
7.53*	0 ± 0	0 ± 0
9.08*	0 ± 0	5 ± 1
9.58*	0 ± 0	6 ± 1
10.51*	2 ± 0	7 ± 2
11.55	3 ± 1	10 ± 2
12.25	4 ± 1	13 ± 2
13.70	12 ± 2	18 ± 4
14.35	26 ± 3	24 ± 4
15.00	34 ± 5	25 ± 5
15.25	31 ± 5	24 ± 5
15.60	42 ± 6	26 ± 5
16.20	44 ± 6	25 ± 6
17.50	48 ± 8	25 ± 7
18.20	52 ± 8	22 ± 8
18.40	35 ± 9	-
18.40	37 ± 9	-
18.70	43 ± 9	16 ± 8
19.10	39 ± 10	22 ± 9
20.50:B	-	21 ± 13
20.60:B	59 ± 13	-
R	51 ± 14	24 ± 14

NGC 2099 (M37)

m_{pg}	Inner Region Rings 1,2,3	Entire Cluster
10.68*	2 ± 1	-6 ± 5
11.72*	93 ± 2	114 ± 9
12.78*	206 ± 4	274 ± 13
13.60	273 ± 6	383 ± 21
13.65	261 ± 6	367 ± 22
14.00	324 ± 8	482 ± 27
14.15	304 ± 8	443 ± 30
14.50	343 ± 10	524 ± 35
14.65	358 ± 10	572 ± 36
15.55	437 ± 13	709 ± 48
17.40	494 ± 21	823 ± 77
17.95	509 ± 24	961 ± 86
18.20	482 ± 25	1028 ± 90
18.60	508 ± 27	938 ± 97
19.35	552 ± 30	1253 ± 107

NGC 2141 / NGC 2194

m_{pg}	NGC 2141 Inner Region Rings 1,2	NGC 2141 Entire Cluster	NGC 2194 Inner Region Ring 1	NGC 2194 Entire Cluster
10.72*	-	-	1 ± 0	0 ± 2
11.45*	-	-	-1 ± 1	0 ± 2
11.75	-	-	10 ± 1	14 ± 5
11.80	-	-	12 ± 1	24 ± 5
12.35*	1 ± 2	0 ± 4	1 ± 2	4 ± 5
13.76*	7 ± 3	16 ± 7	19 ± 2	33 ± 8
14.89*	7 ± 4	12 ± 9	41 ± 3	65 ± 9
16.15	33 ± 6	48 ± 15	60 ± 3	127 ± 12
16.75	49 ± 8	72 ± 18	83 ± 4	172 ± 12
17.10	66 ± 8	95 ± 19	78 ± 4	169 ± 16
17.65	105 ± 10	132 ± 23	95 ± 5	211 ± 18
17.85	140 ± 11	193 ± 25	116 ± 5	273 ± 20
17.90	-	-	121 ± 5	252 ± 20
18.20	216 ± 12	319 ± 28	138 ± 6	326 ± 21
18.25	-	-	122 ± 6	297 ± 22
18.35	244 ± 13	370 ± 30	141 ± 6	306 ± 23
18.40	265 ± 14	390 ± 30	140 ± 6	330 ± 23
18.65	-	-	136 ± 7	361 ± 25
18.75	-	-	141 ± 7	368 ± 26
18.95	326 ± 16	473 ± 37	158 ± 7	439 ± 27
19.30	378 ± 18	582 ± 41	185 ± 8	516 ± 30
19.55:B	578 ± 19	844 ± 44	203 ± 9	541 ± 31

NGC 2158

m_{pg}	Inner Region Rings 1,2	Entire Cluster
10.69*	1 ± 1	2 ± 4
12.85	9 ± 3	22 ± 10
13.65	14 ± 4	24 ± 14
14.00	12 ± 5	30 ± 16
14.35	21 ± 5	54 ± 18
15.35	21 ± 7	65 ± 24
16.00	88 ± 8	166 ± 29
16.70	121 ± 10	214 ± 34
16.90	136 ± 10	225 ± 36
18.00	394 ± 14	531 ± 48
18.50	483 ± 16	662 ± 55
19.00	736 ± 18	960 ± 62
19.25	753 ± 19	1084 ± 66

NGC 2362 (τ CMa)

m_{pg}	fN(m)
6.63*	0 ± 1
7.61*	1 ± 1
8.83*	3 ± 1
10.17*	10 ± 1
11.21*	16 ± 2
12.25*	26 ± 2
13.40	33 ± 3
14.80	37 ± 4
16.00	40 ± 5
17.50	48 ± 8
18.45	40 ± 11
18.75	57 ± 11
20.00	57 ± 15

NGC 2477

m_{pg}	Inner Region Rings 1,2	Entire Cluster
10.1*	0 ± 1	-3 ± 3
11.4*	2 ± 2	0 ± 6
13.1*	40 ± 2	54 ± 8
14.5*	188 ± 5	379 ± 16
15.9*	293 ± 8	610 ± 27
16.8*:	363 ± 10	717 ± 33
18.0::	483 ± 15	1093 ± 51

TABLE II (continued)

m_{pg}	NGC 2506 Inner Region Rings 1,2	NGC 2506 Entire Cluster	NGC 2539 Inner Region Rings 1,2,3	NGC 2539 Entire Cluster
9.15*	-	-	0 ± 0	0 ± 1
10.90*	-	-	1 ± 1	5 ± 4
12.12*	3 ± 2	-2 ± 6	33 ± 2	42 ± 6
13.00*	7 ± 2	1 ± 8	58 ± 3	84 ± 8
13.70*	21 ± 3	18 ± 11	79 ± 5	122 ± 12
15.05	116 ± 6	129 ± 21	89 ± 7	154 ± 17
15.50	128 ± 7	162 ± 22	109 ± 9	177 ± 22
15.85*	108 ± 7	183 ± 22	128 ± 9	247 ± 23
16.15	268 ± 9	387 ± 28	130 ± 12	218 ± 28
16.65	355 ± 10	518 ± 33	130 ± 14	214 ± 34
17.05	413 ± 11	688 ± 38	144 ± 16	229 ± 39
17.20*	511 ± 14	878 ± 45	161 ± 19	261 ± 45
18.00	546 ± 16	925 ± 51	138 ± 21	241 ± 52
18.05*:	589 ± 16	952 ± 54	175 ± 21	293 ± 52
18.40B	559 ± 17	1069 ± 57	-	-
18.65	656 ± 18	1037 ± 60	150 ± 26	210 ± 63

NGC 2682 (M67)

m_{pg}	Inner Region Rings 1,2,3	Entire Cluster
9.78*	1 ± 1	-2 ± 3
10.67*	14 ± 1	11 ± 4
11.10*	14 ± 1	13 ± 4
11.51*	23 ± 1	25 ± 5
11.83*	22 ± 1	26 ± 6
11.95	30 ± 2	36 ± 6
12.30*	41 ± 2	47 ± 7
13.25	59 ± 2	98 ± 10
13.60	87 ± 3	148 ± 11
14.30	143 ± 3	255 ± 13
14.60	163 ± 4	316 ± 14
15.45	186 ± 4	369 ± 17
16.30	222 ± 5	468 ± 21
16.90	250 ± 6	535 ± 23
17.70	264 ± 7	574 ± 27
18.55	294 ± 8	625 ± 30
19.25	297 ± 9	676 ± 34
19.30	295 ± 9	649 ± 35
19.40	312 ± 9	700 ± 35
19.85	320 ± 9	731 ± 38
20.65B	331 ± 10	770 ± 42

NGC 7789

m_{pg}	Inner Region Rings 1,2,3	Entire Cluster
11.07*	0 ± 2	-2 ± 9
12.68*	24 ± 5	55 ± 19
13.14*	31 ± 5	53 ± 20

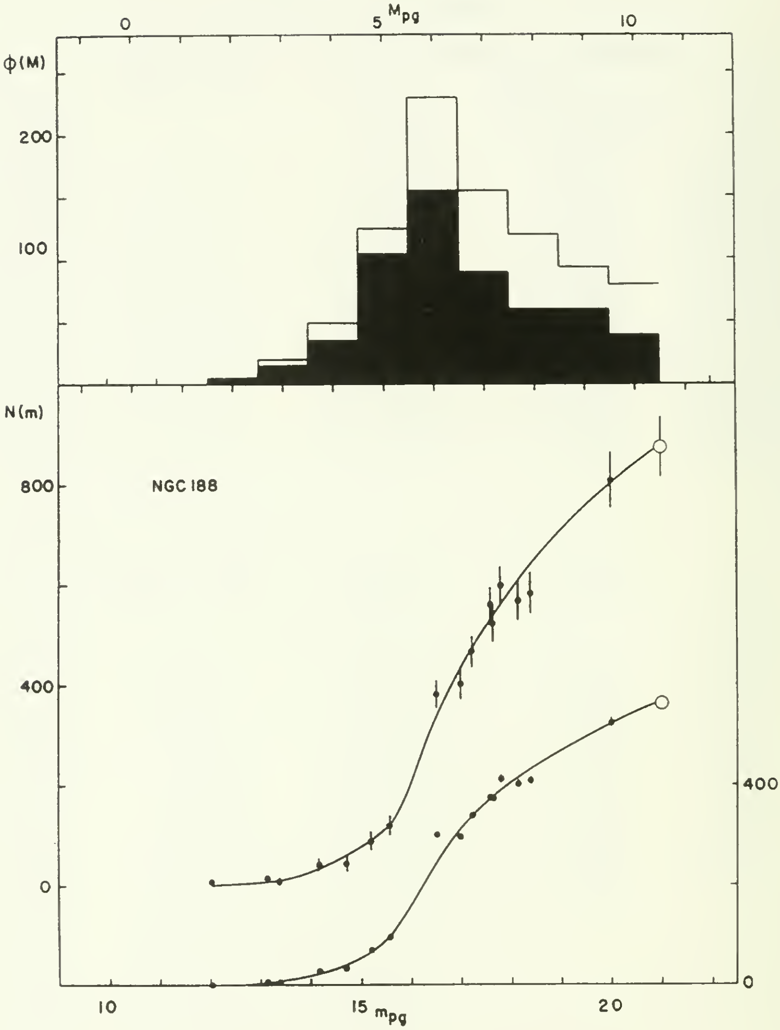
TABLE II (concluded)

NGC 7789 (concluded)

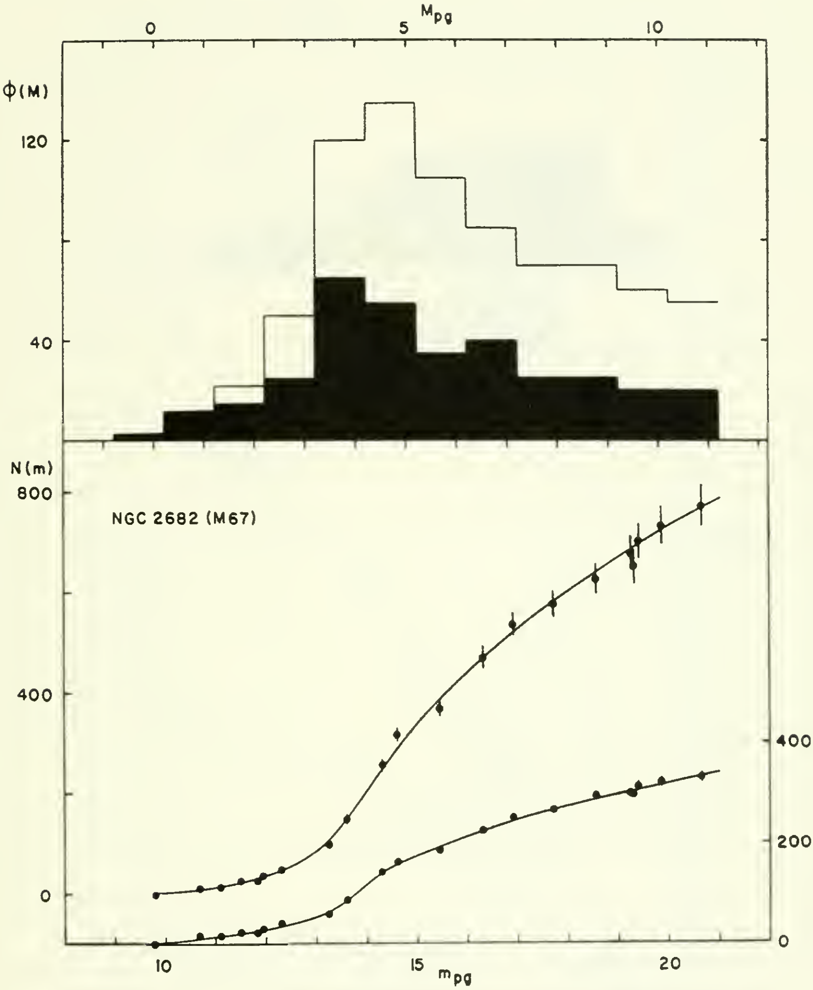
m_{pg}	Inner Region Rings 1,2,3	Entire Cluster
13.88*	59 ± 5	100 ± 22
14.25	149 ± 7	216 ± 30
14.75	240 ± 8	381 ± 35
14.77*	170 ± 8	364 ± 32
15.09*	403 ± 12	811 ± 50
15.15	331 ± 10	601 ± 41
15.45	417 ± 11	737 ± 46
16.49*	621 ± 16	1313 ± 68
17.26*	696 ± 21	1350 ± 89
17.60:	841 ± 24	1661 ± 99
18.00:	937 ± 27	1886 ± 116
18.10:	909 ± 28	1857 ± 119
18.20:	1063 ± 30	1054 ± 126
18.20:	1037 ± 29	2083 ± 125

IC 361

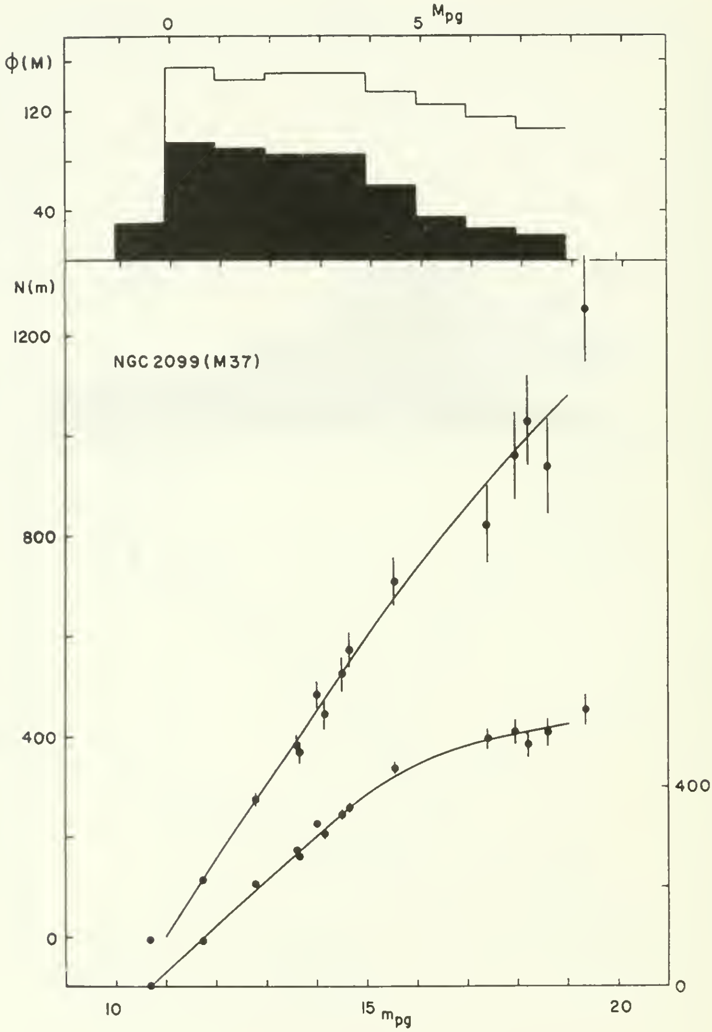
m_{pg}	Inner Region Ring 1	Entire Cluster
14.60	1 ± 1	-5 ± 7
15.50	7 ± 2	-1 ± 10
15.80	18 ± 2	29 ± 11
16.15	33 ± 3	47 ± 12
17.10*	53 ± 3	119 ± 16
17.70	111 ± 4	234 ± 20
18.25	127 ± 5	259 ± 24
18.25	110 ± 5	231 ± 24
18.55	131 ± 6	267 ± 26
18.85	146 ± 6	322 ± 28
19.00	175 ± 6	352 ± 29
20.00:B	187 ± 8	445 ± 38
R	204 ± 11	654 ± 52



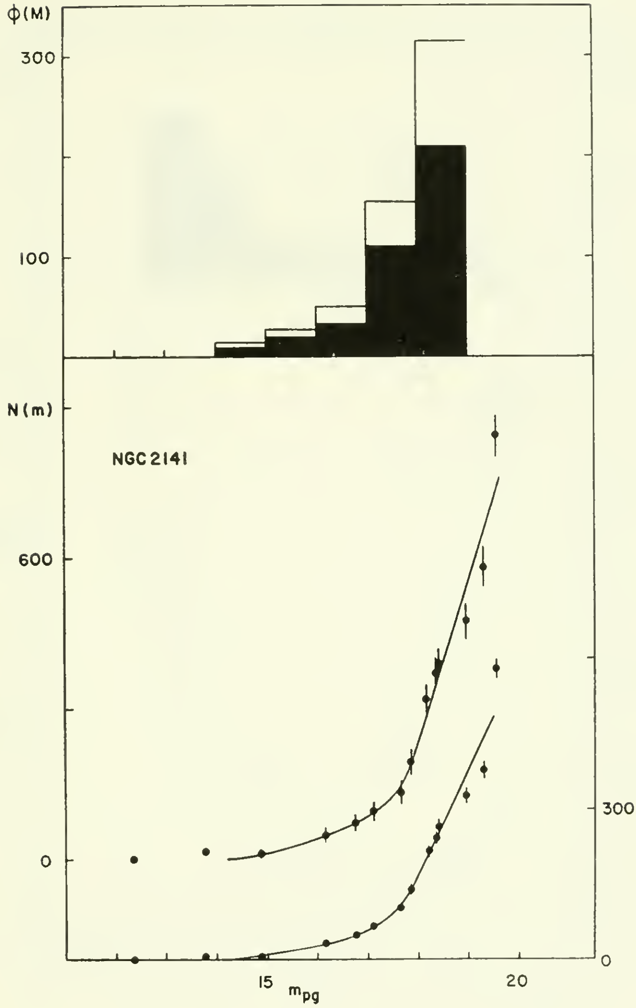
M_{pg}
0
5
10
φ(M)
200
100
N(m)
800
NGC 188
400
0
400
0
10
15 m_{pg}
20



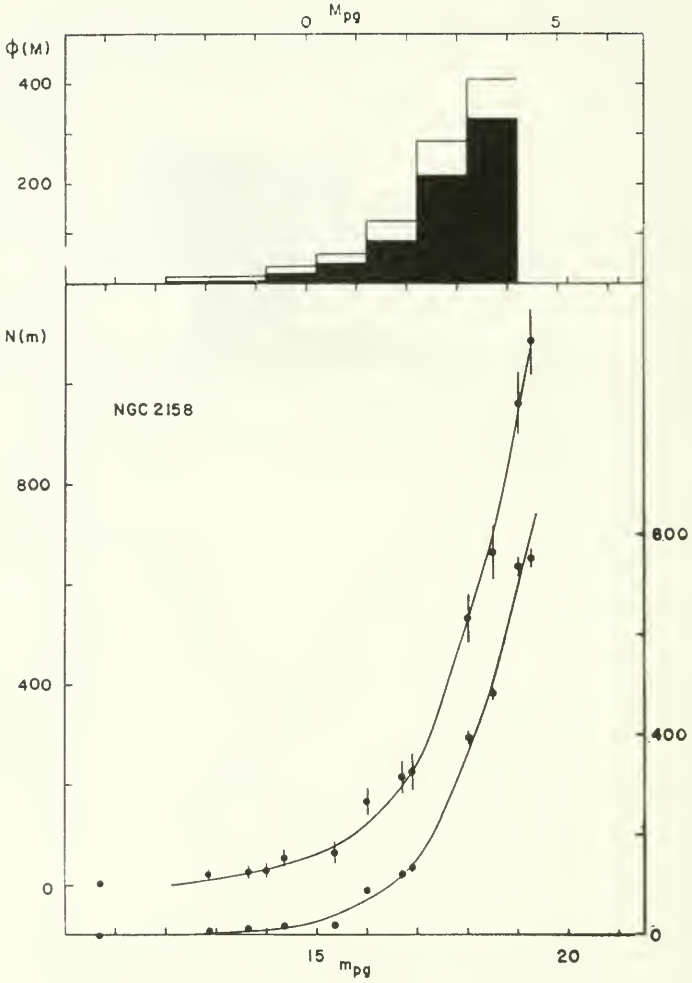
M_{pg}
0
5
10
$\phi(M)$
120
40
N(m)
800
400
0
NGC 2682 (M67)
400
200
0
10
15
20
m_{pg}



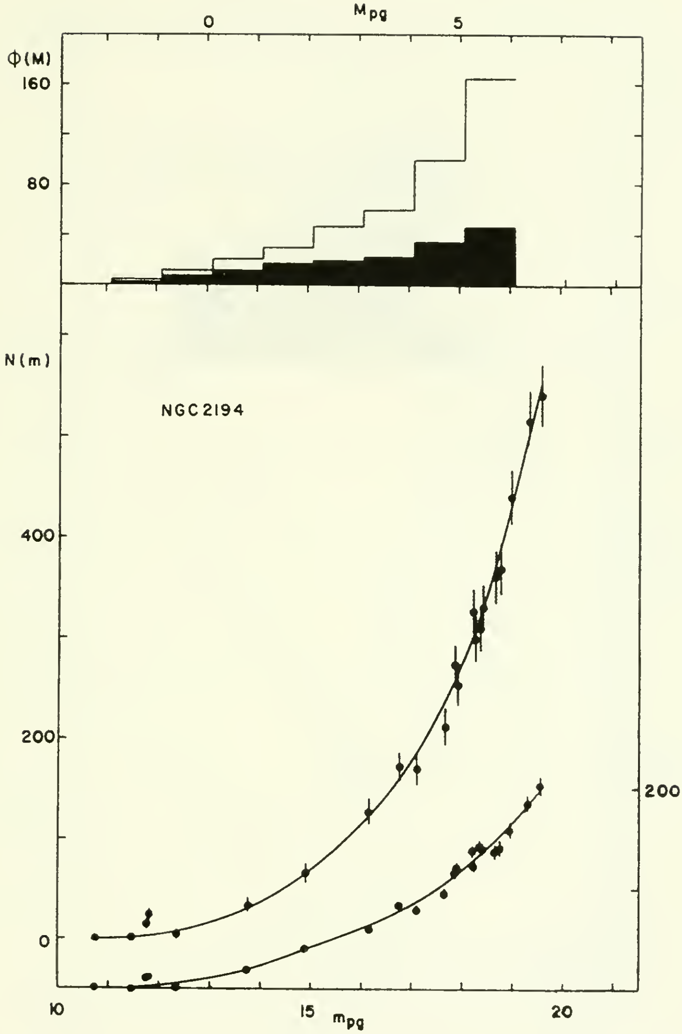
0
5 Mpg
φ(M)
120
40
N(m)
1200
NGC 2099 (M37)
800
400
0
400
0
10
15 mpg
20



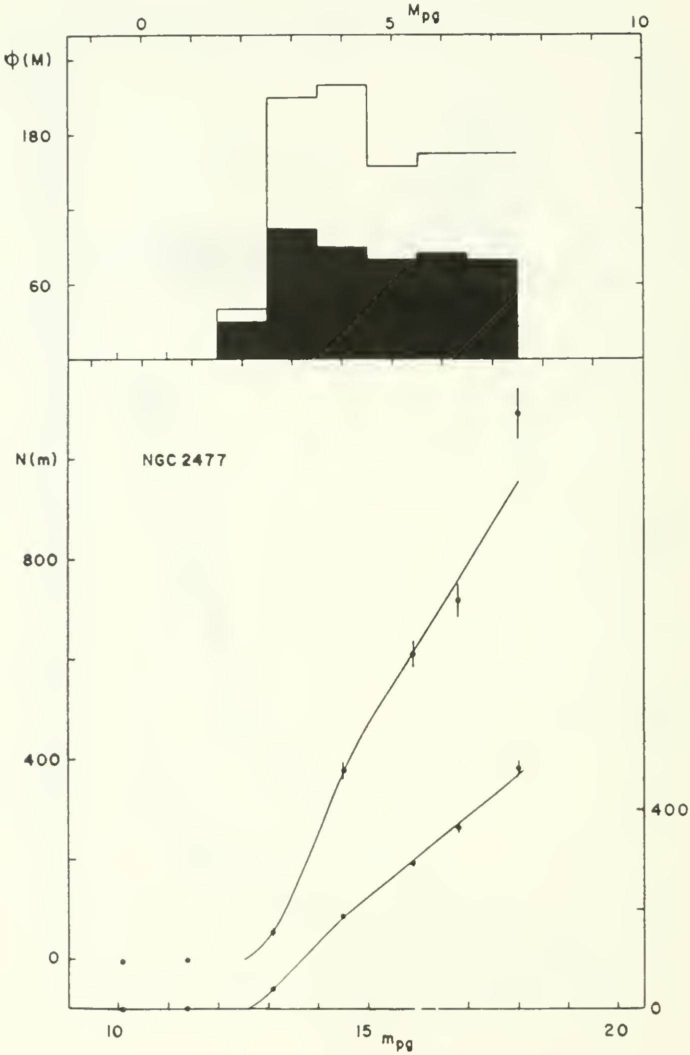
φ(M)
300
100
N(m)
NGC 2141
600
0
300
0
15
m_pg
20



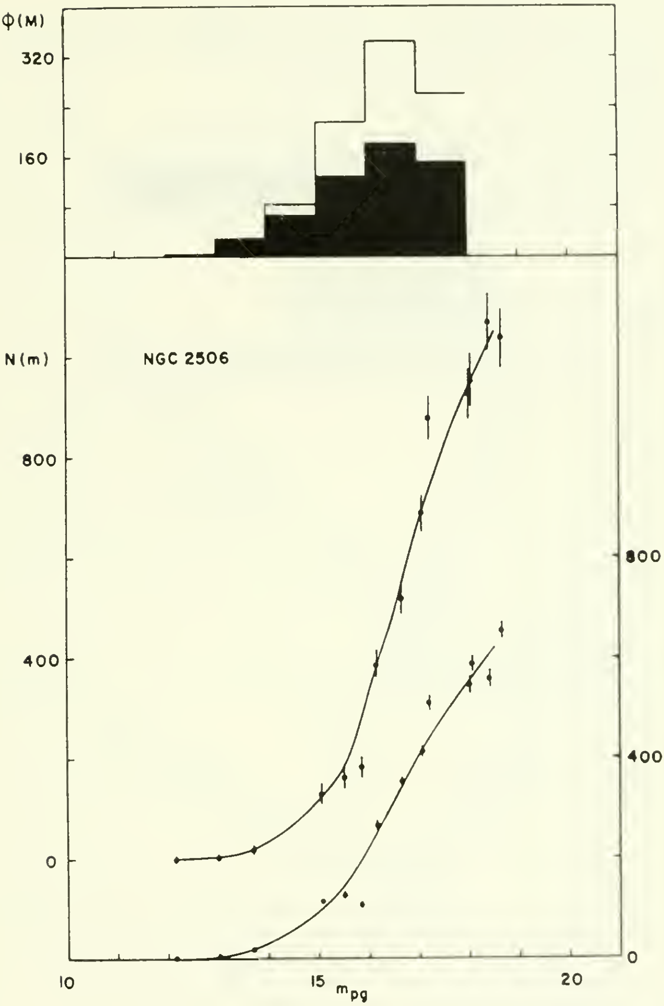
M_{pg}
0
5
Φ(M)
400
200
N(m)
NGC 2158
800
400
0
800
400
0
15
20
m_{pg}



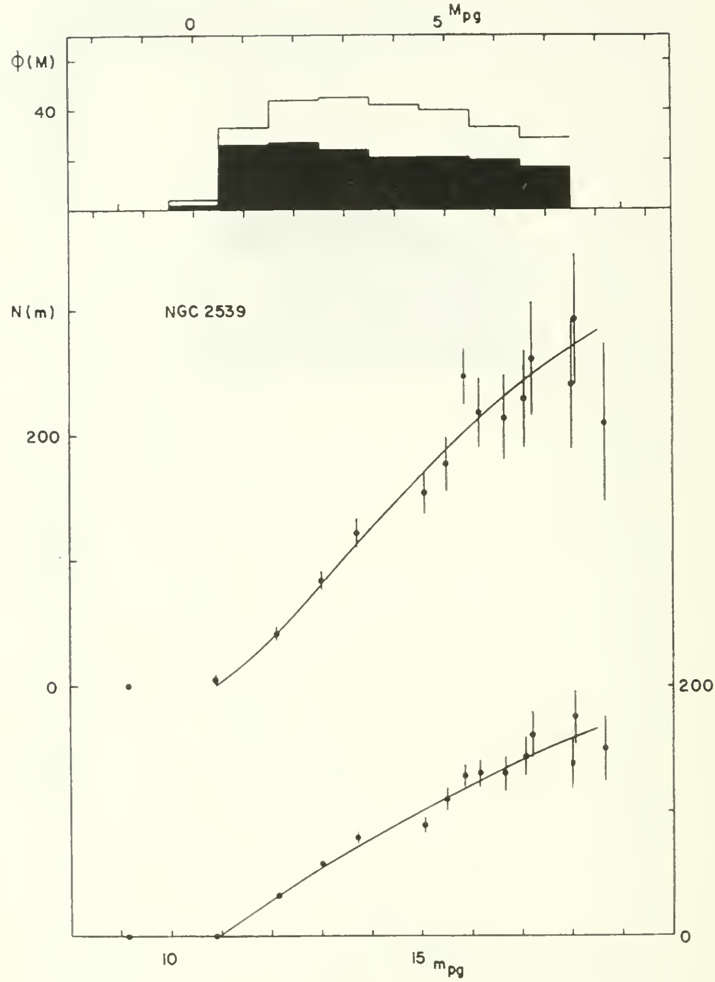
M pg
0
5
Φ(M)
160
80
N(m)
NGC 2194
400
200
0
200
10
15
m pg
20



0
5 M_{pg}
10
Φ(M)
180
60
N(m)
NGC 2477
800
400
0
400
0
10
15 m_{pg}
20



Φ(M)
320
160
N(m)
NGC 2506
800
400
0
800
400
0
10
15
m_{pg}
20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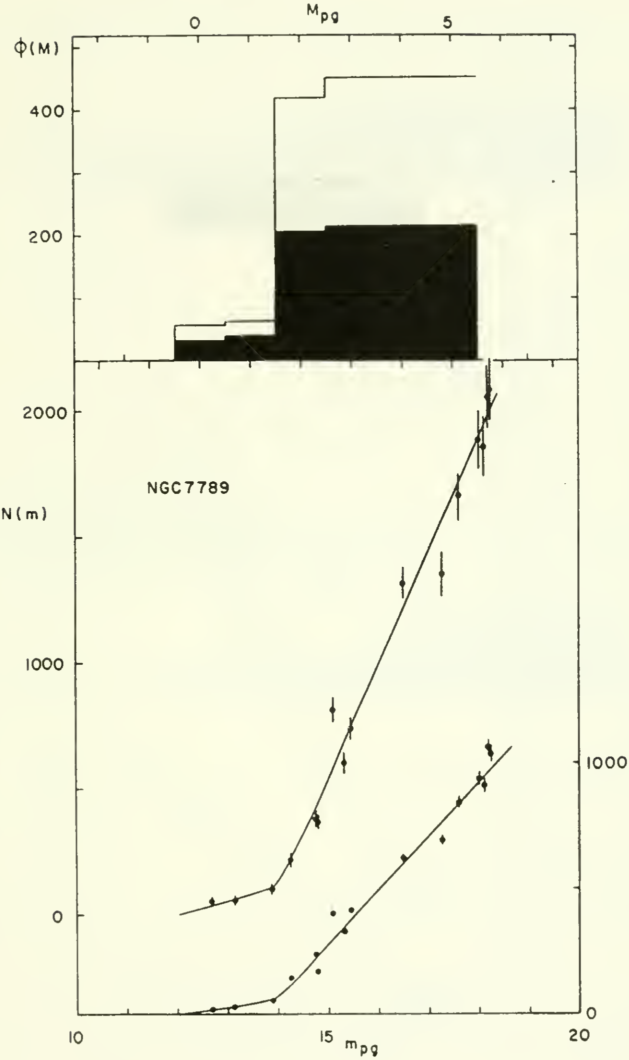
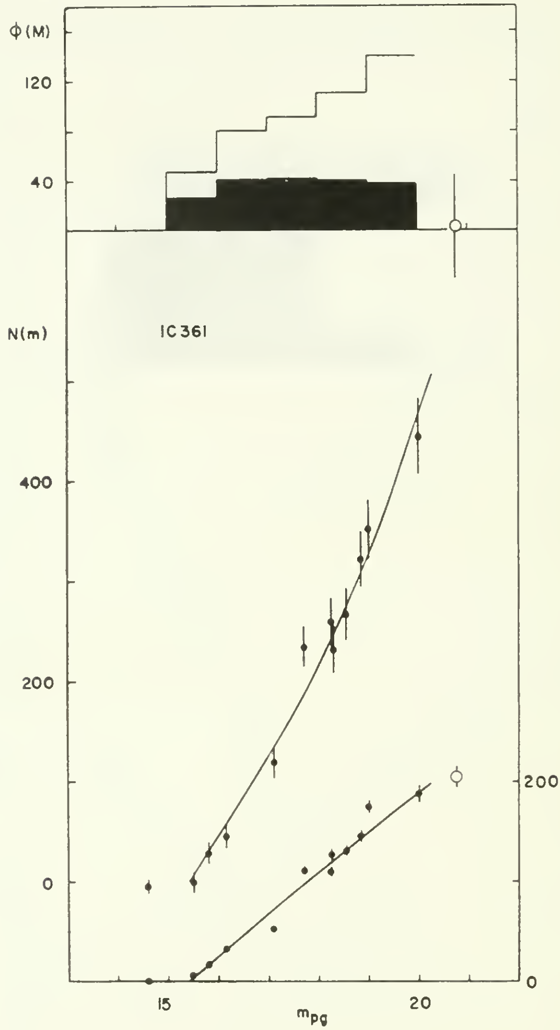
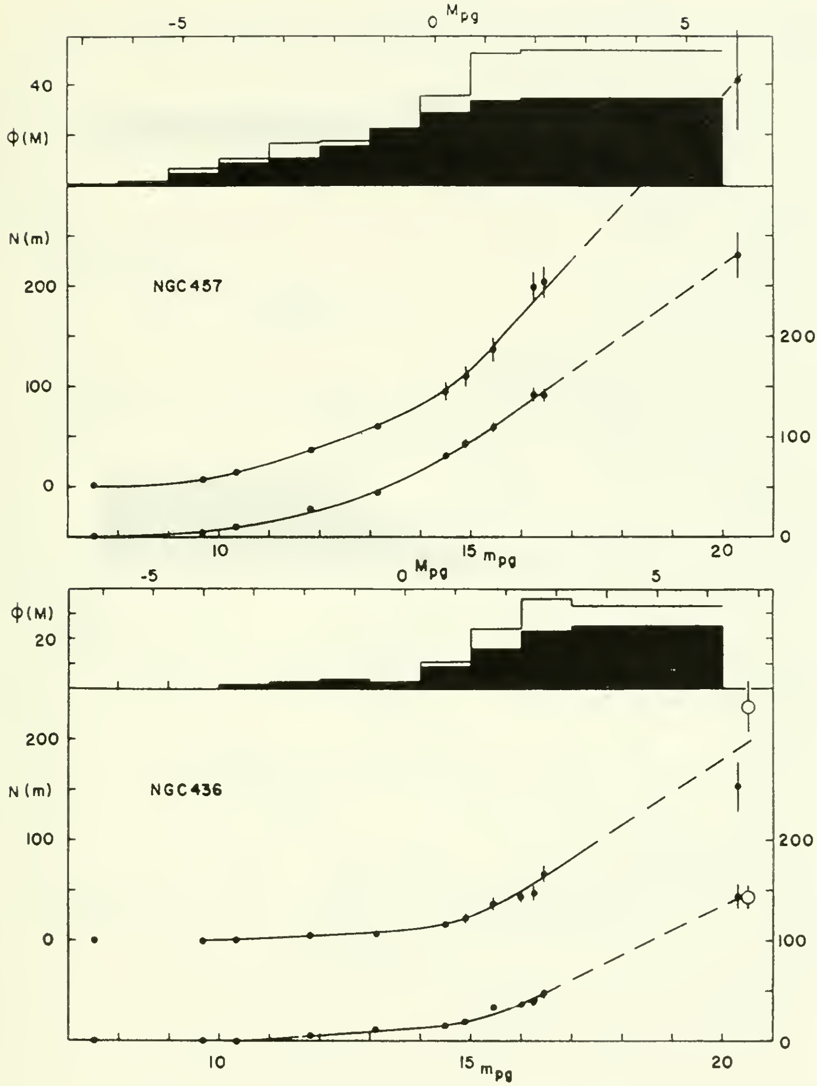
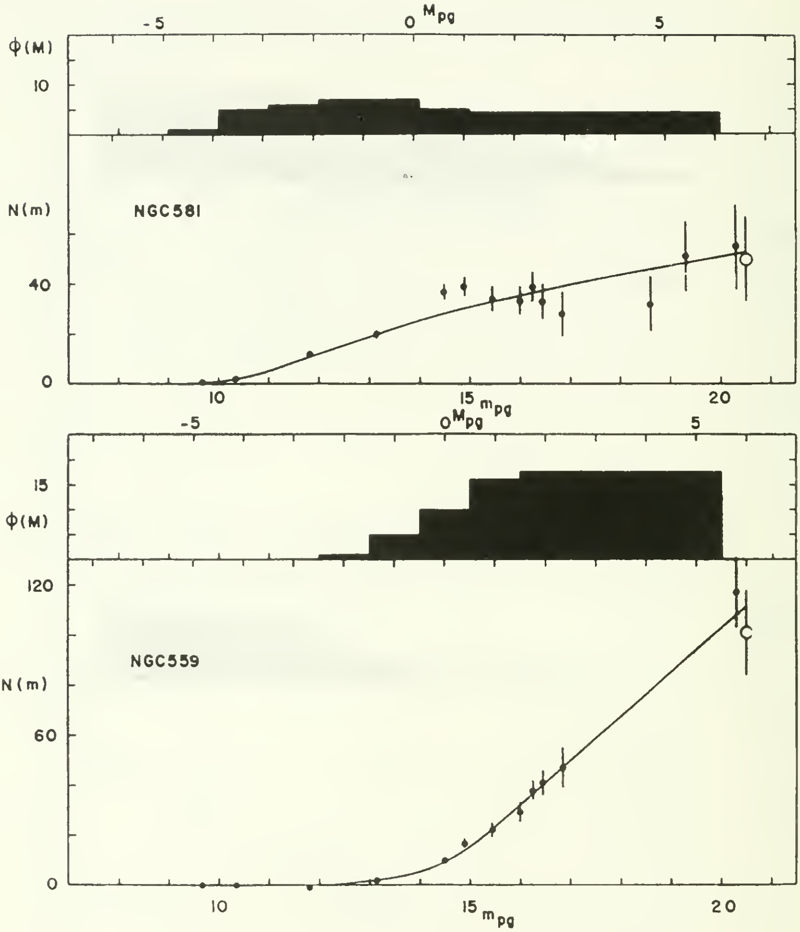
N(m)
NGC 2539
200
0
200
0
10
15 mpg

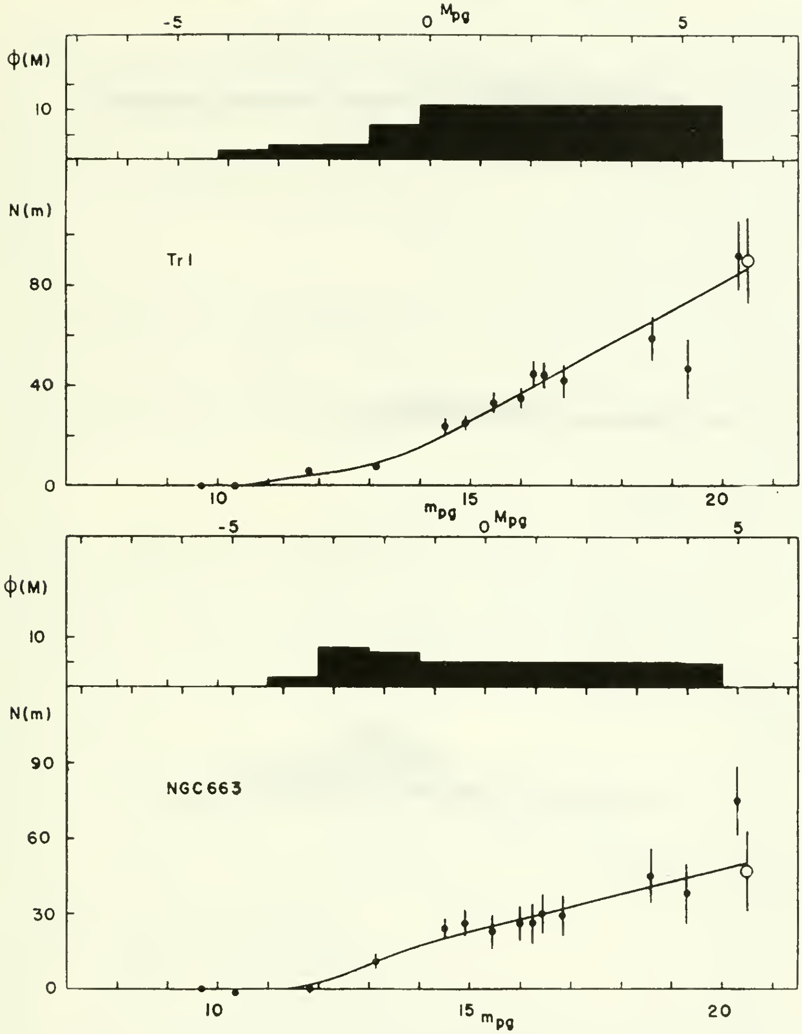


M_{pg}
0
5
$\phi(M)$
400
200
2000
NGC7789
N(m)
1000
0
1000
0
10
15
m_{pg}
20

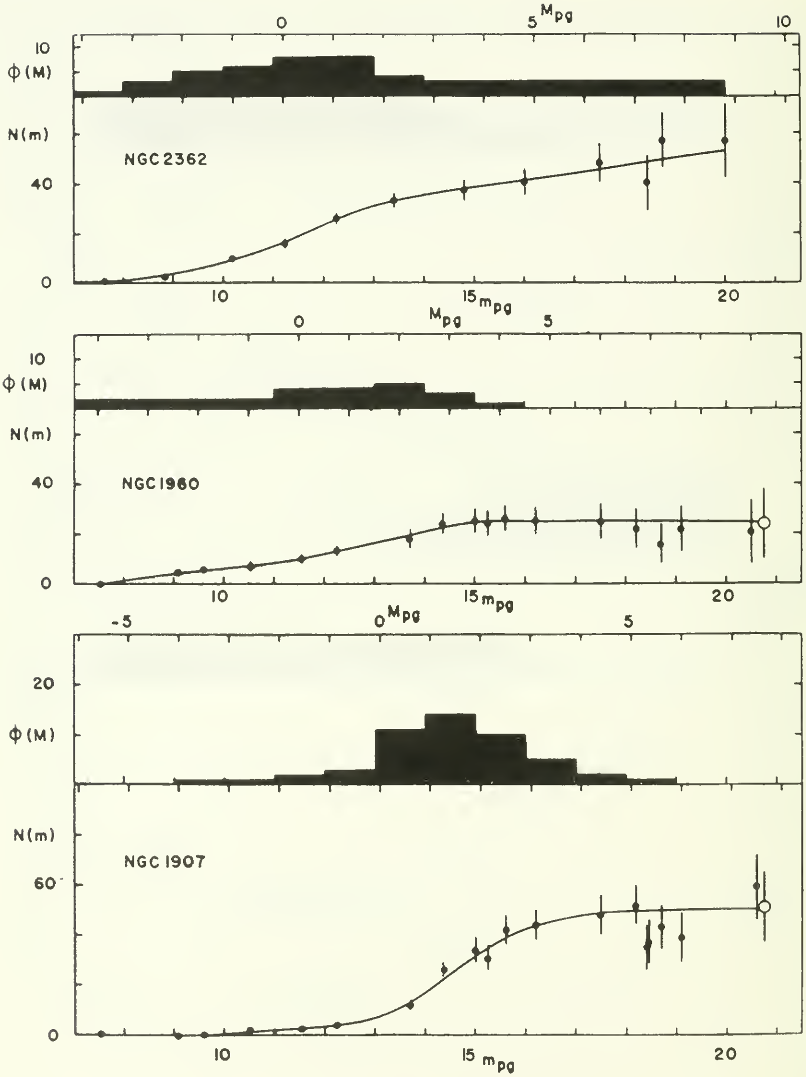

Φ(M)
120
40
N(m)
IC 361
400
200
0
200
0
15
20
m_{pg}


M_{pg}
-5
0
5
40
Φ(M)
N(m)
200
100
0
NGC457
200
100
0
10
15
20
m_{pg}
-5
0
5
Φ(M)
20
200
N(m)
100
0
NGC436
200
100
0
10
15
20
m_{pg}


-5
0 M_{pg}
5
ϕ(M)
10
N(m)
NGC581
40
0
10
15 m_{pg}
20
-5
0 M_{pg}
5
15
ϕ(M)
120
NGC559
N(m)
60
0
10
15 m_{pg}
20



M_{pg}
-5
0
5
$\phi(M)$
10
N(m)
Tr I
80
40
0
10
15
20
m_{pg}
M_{pg}
-5
0
5
$\phi(M)$
10
N(m)
90
NGC663
60
30
0
10
15
20
m_{pg}



0
5 Mpg
10
10
φ(M)
N(m)
NGC 2362
40
0
10
15 mpg
20
0
Mpg
5
10
φ(M)
N(m)
NGC 1960
40
0
10
15 mpg
20
-5
0 Mpg
5
20
φ(M)
N(m)
NGC 1907
60
0
10
15 mpg
20

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References

Allen, C. W. 1955, "Astrophysical Quantities", (London: The Athlone Press) p. 180.
van den Bergh, S. 1957. *A. J.*, vol. 62, p. 100.
Bodén, E. 1951, *Uppsala Ann.*, vol. 2, no. 10.
Burbidge, E. M. and Sandage, A. R. 1958, *Ap. J.*, vol. 128, p. 174.
Chandrasekhar, S. 1942, "Principles of Stellar Dynamics", (Chicago: Univ. of Chicago Press) p. 234.
Cuffey, J. 1937a, *Harv. Ann.*, vol. 105, p. 403.
Cuffey, J. 1937b, *Harv. Ann.*, vol. 106, p. 39.
Cuffey, J. 1943, *Ap. J.*, vol. 97, p. 93.
Hiltner, W. A. 1956, *Ap. J. Suppl.*, vol. 2, p. 389.
Johnson, H. L. and Morgan, W. W. 1953, *Ap. J.*, vol. 117, p. 313.
Johnson, H. L. and Sandage, A. R. 1955, *Ap. J.*, vol. 121, p. 616.
Johnson, H. L. 1957, *Ap. J.*, vol. 126, p. 121.
Johnson, H. L. 1959, *Lowell Obs. Bull.*, vol. 4, p. 37.
King, I. R. 1959, *A. J.*, vol. 64, p. 351.
Kruspán, E. 1959, *Zs. f. Ap.*, vol. 48, p. 1.
Lindblad, P. O. 1954, *Stockholm Ann.*, vol. 18, no. 1.
Pesch, P. 1959, *Ap. J.*, vol. 130, p. 764.
Sandage, A. R. 1957, *Ap. J.*, vol. 125, p. 422.
Sawyer, H. B. 1930, *Harvard Obs. Bull.*, no. 875, p. 16.
Schmidt, M. 1959, *Ap. J.*, vol. 129, p. 243.
Walker, M. F. 1956, *Ap. J. Suppl.*, vol. 2, p. 365.
Zug, R. S. 1933, *Lick Obs. Bull.*, vol. 16, p. 119.

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VOLUME II NUMBER 8

SPECTROGRAPHIC ORBITS FOR THE ECLIPSING SYSTEMS V548 CYGNI, V805 AQUILAE AND V451 OPHIUCHI

JOHN F. HEARD AND DONALD C. MORTON

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TORONTO, CANADA

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SPECTROGRAPHIC ORBITS FOR THE ECLIPSING SYSTEMS V548 CYGNI, V805 AQUILAE AND V451 OPHIUCHI

By John F. Heard and Donald C. Morton*

Abstract

The orbital elements of these three eclipsing systems have already been published in an abstract by Heard and Morton (1956). These elements are unchanged in the present paper, but the observational data are here recorded in full, and the orbits are discussed in detail. Photometric elements are available for all three systems from the work of other authors. Thus, for the systems V805 Aql and V451 Oph, which are solved spectrographically for both stellar components, it has been possible to combine spectrographic and photometric results to obtain absolute values of diameters, masses and bolometric magnitudes.

V548 Cygni

This star, V548 Cygni, H.D. 189371, α (1900) $19^h\ 54^m\!.6$, δ (1900) $+54°32'$, m_{pg} 8.90–9.72, sp. A0, was once listed as an RR Lyrae variable (see I.A.U., 1951). The late Professor A. Colacevich observed it photoelectrically at Naples and recognized it as an Algol-type system with a period of about 1.8 days. Fresa (1956) has analysed the light curve resulting from the Naples observations and has determined elements of the photometric orbit.

During 1954 and 1955 thirty-six spectrograms of V548 Cyg were obtained here with dispersion 33 A./mm. The velocities from these were used to obtain the spectrographic orbit. The spectral lines are broad; on most of the plates only the hydrogen lines and λ3933 of Ca II and λ4481 of Mg II were measurable. Lines of the secondary spectrum were not seen with sufficient certainty for velocity measures.

The period reported by Fresa (1956), namely 1.805257 days, fitted our observations well and was accepted for our solution. The other elements were obtained first by the precomputed curves of R. K. Young, and then were corrected by a computer method of least squares reported by Heard and MacRae (1957). Table I lists the preliminary and final elements along with the mean errors; Table II lists the observed and computed velocities; figure 1 shows the velocity curve.

There is a contradiction between the value of ω (94°) derived here from the spectrographic data and the value, 316°, derived by Fresa

*Now at Princeton University Observatory.

TABLE I

ORBITAL ELEMENTS FOR V548 CYG

Element		Preliminary	Final	m.e.
Period	P	1.805257 days (Fresa)		
Eccentricity	e	0.10	0.11	±0.03
Angle of periastron	ω	90°	94°	±17°
Periastron passage	T	J.D. 2435336.356	J.D.2435336.383	±0.084
Velocity of the system	γ	−22.5 km./sec.	−22.4 km./sec.	±2.9
Semi-amplitude	K	68.5 km./sec.	66.7 km./sec.	±1.9
$a \sin i$			1.65×10^6 km.	

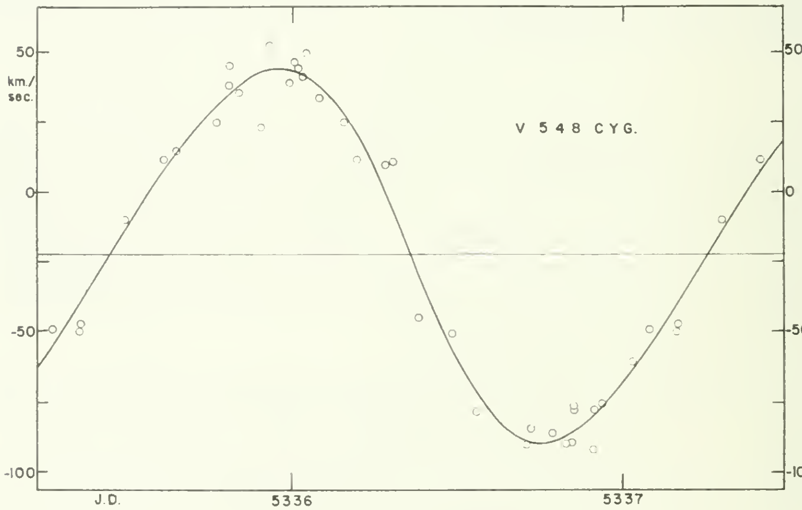

FIGURE 1.

(1956) from the photometric data, although our value of e agrees with Fresa's value of 0.10. Regardless of the fact that neither Fresa's nor our value of ω is very precise, the contradiction is inherent in the forms of the light curve and the velocity curve; in the light curve the secondary eclipse follows the primary by appreciably more than half the period, which is consistent with a value of ω in the general neighbourhood of 360°, whereas the velocity curve is almost precisely the form given by an orbit of $\omega = 90°$.

If we compute the time of the minima from our spectrographic elements and then use Fresa's period (over about 600 cycles) to compare these with his, we get:

For primary minimum, Fresa: J.D. 2434298.393
ours: J.D. 2434298.342
For secondary minimum, Fresa: J.D. 2434299.373
ours: J.D. 2434299.240

TABLE II

RADIAL VELOCITY OBSERVATIONS OF V548 CYG

J.D.	V_o km./sec.	Phase from final T	V_c km./sec.	$V_o - V_c$ km./sec.
2434932.789	−51.0	0.784	−40.3	−10.7
933.813	−44.4	0.003	−28.5	−15.9
934.730	−10.2	0.920	−15.1	+ 4.9
935.778	−78.4	0.162	−69.3	− 9.1
936.815	+24.7	1.199	+30.3	− 5.6
937.768	−84.5	0.347	−89.5	+ 5.0
938.780	+52.4	1.359	+43.1	+ 9.3
939.785	−75.9	0.559	−76.6	+ 0.7
946.779	−90.2	0.332	−89.1	− 1.1
947.683	+38.1	1.236	+34.5	+ 3.6
949.710	+40.9	1.457	+42.2	− 1.3
950.762	−49.2	0.704	−54.7	+ 5.5
956.746	+35.8	1.272	+38.0	− 2.2
957.755	−76.1	0.476	−85.2	+ 9.1
958.694	+39.2	1.415	+43.6	− 4.4
960.671	+25.3	1.587	+27.4	− 2.1
961.674	−47.8	0.785	−40.3	− 7.5
968.644	−92.3	0.534	−79.6	−12.7
2435083.461	+11.6	1.619	+21.3	− 9.7
262.819	−89.9	0.452	−86.9	− 3.0
280.831	−85.9	0.411	−89.0	+ 3.1
291.788	−78.1	0.537	−79.2	+ 1.1
292.757	+33.4	1.506	+38.5	− 5.1
301.712	+46.5	1.434	+43.1	+ 3.4
302.735	−60.9	0.652	−63.3	+ 2.4
335.653	+14.7	1.075	+12.3	+ 2.4
338.658	−89.9	0.470	−85.7	− 4.2
339.652	+49.6	1.464	+41.8	+ 7.8

TABLE II—*Continued*

J.D.	V_o km./sec.	Phase from final T	V_c km./sec.	$V_o - V_c$ km./sec.
2435341.698	+ 9.6	1.705	+ 0.9	+ 8.7
343.711	−50.6	0.107	−56.9	+ 6.3
350.747	+11.3	1.727	− 5.0	+16.3
353.669	+11.5	1.039	+ 6.3	+ 5.2
355.767	+23.0	1.332	+42.1	−19.1
356.719	−77.8	0.478	−85.0	+ 7.2
357.682	+44.4	1.441	+42.9	+ 1.5
373.724	+45.1	1.236	+34.5	+10.6

V805 Aquilae

This star, V805 Aquilae, H.D. 177708, α (1900) $19^h00^m.7$, δ (1900) $-11°48'$, m_{pg} 7.81–8.48, sp. A2, was identified as an Algol-type eclipsing variable by Bakos (1950) who assigned to it a period of 1.20409 days.

From photoelectric observations made at Naples in 1952 Fresa (1954) has found that there are two unequal minima and that the period is twice that assigned by Bakos. Fresa analysed the light curve and determined the elements of the photometric orbit.

Between July 10, 1953 and August 16, 1955, twenty-nine spectrograms of V805 Aql were obtained here with dispersion 33 A./mm. It is these which have been used to obtain the spectrographic orbit reported here.

Both primary and secondary spectra are visible, the primary considerably the stronger. In the primary spectrum many lines are measurable, but in the secondary the lines are so weak that only the few strongest of them could be measured near the phases of extreme velocities.

Fresa's period of 2.408230 days fitted our observations well; no attempt was made to improve it. From the velocity curve for the primary, preliminary elements were obtained by the use of R. K. Young's precomputed curves, and then least-squares corrections to five elements were obtained by a computer method of Heard and MacRae (1957).

As for the secondary component, the velocities were used only for the purpose of determining the value of K_2 by least squares, the other elements being regarded as fixed by the solution for the primary.

The preliminary and final elements are listed in Table III, the velocity curves are shown in figure 2, and the observed and calculated

TABLE III

Orbital Elements for V805 Aql

Element	Preliminary	Final	m.e.
Period	P 2.408230 days (Fresa)		
Eccentricity	e 0	0.018	± 0.009
Angle of periastron	ω	$37° \pm 31°$	
Periastron passage	T	J.D.2434959.513	± 0.2
Velocity of the system	γ -39 km./sec.	-39.6	± 0.7
Semi-amplitude, primary	K_1 107 km./sec.	106.2	± 0.9
" " secondary	K_2 127 km./sec.	130.5	± 5.7
$a_1 \sin i$, primary		3.5×10^6 km.	
$a_2 \sin i$, secondary		4.32×10^6 km.	

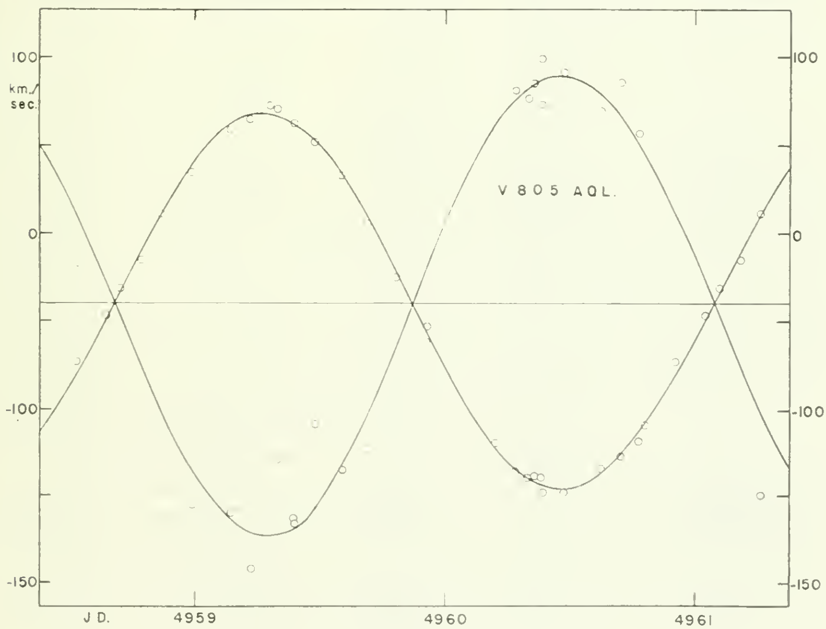

Figure 2.

velocities are listed in Table IV (in which the velocity of the primary component is always listed first).

When we compute the expected time of eclipses from the spectrographic orbit and compare them with Fresa's observed times (using his period), we find no significant discordance.

TABLE IV

RADIAL VELOCITY OBSERVATIONS OF V805 AQL

J.D.	V_o km./sec.	Phase from final T	V_c km./sec.	$V_o - V_c$ km./sec.
2434567.661	−119.0	0.690	−122.5	+ 3.5
568.722	+ 11.3	1.751	+ 9.8	+ 1.5
	−148.7		−100.3	−48.4
934.692	− 15.0	1.670	− 11.0	− 4.0
935.720	− 24.7	0.290	− 23.8	− 0.9
937.716	+ 62.3	2.286	+ 62.6	− 0.3
	−165.1		−166.4	+ 1.3
938.656	−138.9	0.817	−138.6	− 0.3
	+ 76.5		+ 82.1	− 5.6
939.709	+ 34.3	1.870	+ 36.3	− 2.0
	−154.4		−133.1	−21.3
946.649	− 30.8	1.586	− 33.5	+ 2.7
949.657	+ 72.6	2.186	+ 67.9	+ 4.7
950.653	−135.4	0.773	−134.4	− 1.0
	+ 81.0		+ 76.6	+ 4.4
958.634	− 46.9	1.530	− 48.6	+ 1.7
960.625	−133.0	1.112	−135.1	+ 2.1
	+ 70.3		+ 77.6	− 7.3
961.622	+ 65.0	2.109	+ 66.7	− 1.7
	−190.8		−170.4	−20.4
967.608	−138.2	0.871	−142.5	+ 4.3
	+ 99.2		+ 86.6	+12.6
971.619	+ 33.7	0.065	+ 33.8	− 0.1
	−133.7		−129.8	− 3.9
981.598	− 61.5	0.411	− 57.9	− 3.6
982.594	− 72.6	1.407	− 80.4	+ 7.8
2435006.531	−118.3	1.262	−112.4	− 5.9
	+ 57.1		+ 49.9	+ 7.2
261.828	−108.2	1.287	−107.5	− 0.7
262.762	+ 70.8	2.221	+ 67.1	+ 3.7
	−131.7		−170.6	+38.9

TABLE IV—*Continued*

J.D.	V_o km./sec.	Phase from final T	V_c km./sec.	$V_o - V_c$ km./sec.
2435279.765	+ 52.0	2.366	+ 53.2	− 1.2
	−108.1		−153.6	+45.5
280.770	−146.6	0.963	−144.2	− 2.4
	+ 90.5		+ 88.8	+ 1.7
291.729	+ 62.3	2.289	+ 62.5	− 0.2
	−162.2		−165.0	+ 2.8
292.692	−137.8	0.844	−140.3	+ 2.5
	+ 85.3		+ 84.1	+ 1.2
301.650	+ 7.1	0.169	+ 9.2	− 2.1
	−123.0		− 99.6	−23.4
302.675	−126.6	1.194	−124.1	− 2.5
	+ 85.5		+ 64.3	+21.2
321.624	−146.6	0.877	−142.7	− 3.9
	+ 73.2		+ 87.1	−13.9
327.593	+ 59.2	2.029	+ 60.8	− 1.6
	−157.9		−162.9	+ 5.0
335.610	− 52.6	0.414	− 58.8	+ 6.2

V451 Ophiuchi

The star V451 Ophiuchi, H.D. 170470, α (1900) $18^{h}24^{m}.5$, δ (1900) $+10°49'$, m_{pg} 7.86–8.46, sp. A0, was identified as an Algol-type eclipsing variable by Hoffmeister (1935). Colacevich (1953) studied the light variations in detail and determined photometric elements. At that time, on the basis of five radial velocities for 1936, 1939 and 1940 which were supplied to him by one of us (J. F. H.), he determined the amplitudes of the velocity variations of both components, and combined these with his photometric data to determine the dimensions, mass and absolute magnitudes of the stars.

Between 1952 and 1955, thirty-nine additional radial-velocity observations of this star were made here. The original five observations had been made with a dispersion of 66 A./mm.; most of the additional ones were made with 33 A./mm. dispersion and were much superior in quality. Of these higher dispersion spectrograms, twenty-three were selected on which double lines were clearly seen. These form the basis of the spectrographic orbit here reported.

All lines in the spectrum of both components are much broadened, so that only the stronger lines (those of hydrogen, λ3933 of Ca II and λ4481 of MgII) could be measured, and only at phases near the maxima of velocity could the double lines be resolved. The result is that the velocity curves are not distinguishable from sine curves; therefore the orbital eccentricity was taken as zero. (Colacevich, 1953, obtained $e = 0.025$ from the photometric orbit.) Furthermore, the velocity observations over the whole 16 years of our observations were well satisfied by Colacevich's period of 2.1965962 days; therefore the period was not included in our solution. Likewise Colacevich's epoch of primary eclipse, J.D. 2434165.499, was consistent with our velocity observations, and we assumed the corresponding epoch of the ascending node of the brighter component, namely J.D. 2434164.950 (or J.D. 2434237.438 as brought forward to the time of our observations). Therefore our least-squares solution was made for three unknowns only, namely the velocity of the system and the two semi-amplitudes of velocity. Table V gives preliminary and final elements so derived.

TABLE V

Orbital Elements for V451 Oph

Element	Preliminary	Final	m.e.
Period	P 2.1965962 days (Colacevich)		
Eccentricity	e 0		
Epoch of ascending node of primary component	J.D.2434237.438		
Velocity of the system	γ −15.0 km./sec.	−14.7 km./sec.	±2.0
Semi-amplitude, primary	K_1 120 km./sec.	121.1 km./sec.	±3.3
" " secondary	K_2 145 km./sec.	145.7 km./sec.	±3.3
$a_1 \sin i$, primary		3.66×10^6 km.	
$a_2 \sin i$, secondary		4.40×10^6 km.	

In a later section we give the values for the dimensions, masses and absolute magnitudes of the component stars as derived from a combination of the photometric and spectrographic elements. These are more accurate than those given by Colacevich (1953) who used very rough values of K_1 and K_2 derived, as stated above, from only five of our early observations.

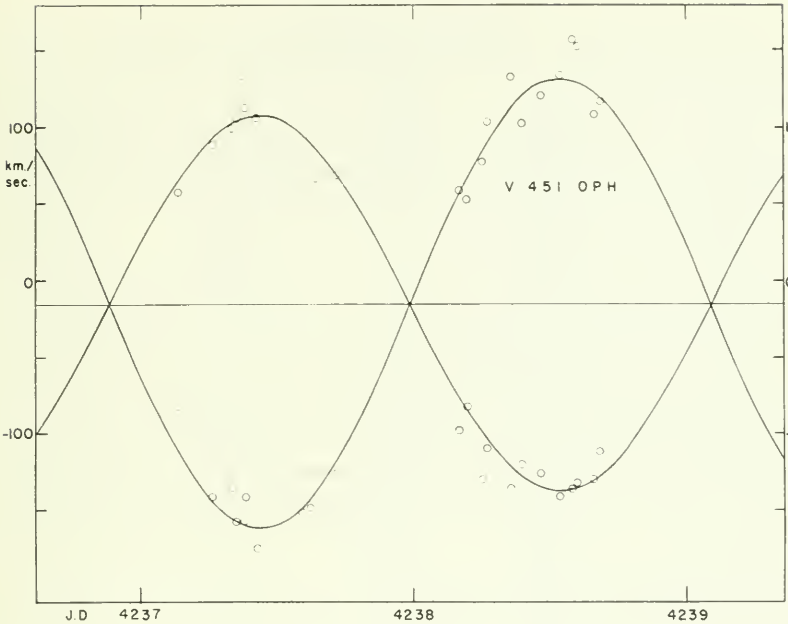

FIGURE 3.

Figure 3 shows the velocity curves, and Table VI lists the observed and computed velocities, the primary component being listed first in each case.

TABLE VI

RADIAL VELOCITY OBSERVATIONS OF V451 OPH

J.D.	V_o km./sec.	Phase from final T	V_c km./sec.	$V_o - V_c$ km./sec.
2434237.640	+ 65.9	1.850	+ 86.6	−20.7
	−124.0		−136.6	+12.6
238.678	−109.8	0.691	−126.0	+16.2
	+116.2		+119.2	− 3.0
242.647	−128.1	0.267	− 98.5	−29.6
	+ 77.4		+ 86.1	− 8.7
248.696	+ 68.4	1.923	+ 70.6	− 2.2
	−124.1		−117.4	− 6.7
249.640	−128.2	0.670	−128.6	+ 0.4
	+107.7		+122.4	−14.7

TABLE VI—*Continued*

J.D.	V_o km./sec.	Phase from final T	V_c km./sec.	$V_o - V_c$ km./sec.
2434251.641	−124.7	0.475	−133.1	+ 8.4
	+120.1		+127.7	− 7.6
252.638	+ 88.3	1.472	+ 92.0	− 3.7
	−140.4		−143.0	+ 2.6
543.681	−134.6	0.367	−119.7	−14.9
	+131.8		+111.7	+20.1
622.599	− 81.1	0.208	− 84.0	+ 2.9
	+ 53.0		+ 68.6	−15.6
623.681	+ 57.1	1.290	+ 48.4	+ 8 7
	− 81.8		− 90.7	+ 8.9
639.593	+ 75.3	1.826	+ 90.9	−15.6
	−146.8		−141.8	− 5.0
663.514	+132.6	1.584	+104.4	+28.2
	−155.9		−158.0	+ 2.1
664.525	−118.0	0.399	−124.8	+ 6.8
	+102.5		+117.8	−15.3
666.500	− 95.9	0.177	− 73.6	−22.3
	+ 58.3		+ 56.1	+ 2.2
685.487	+111.7	1.591	+104.8	+ 6.9
	−139.7		−158.5	+18.8
2435245.824	+ 72.7	1.796	+ 95.6	−22.9
	−150.3		−147.4	− 2.9
246.818	−134.1	0.594	−134.8	+ 0 7
	+157.0		+129.8	+27.2
269.748	+105.3	1.558	+102.5	+ 2.8
	−155.3		−155.7	+ 0.4
279 719	−139.4	0.546	−135.8	− 3.6
	+133.5		+131.0	+ 2.5
280.710	+ 98.4	1.537	+100.4	− 2.4
	−134.2		−153.2	+19.0
292.632	−107.6	0.279	−101.4	− 6.2
	+103.4		+ 89.6	+13.8
301.748	−130.2	0.609	−134.3	+ 4 1
	+152.5		+129.2	+23.3
302.776	+105.8	1.637	+106.4	− 0.6
	−174.7		−160 3	−14.4

Masses and Luminosities of V805 Aql and V451 Oph

When a binary system has been solved both photometrically and as a double-line spectrographic binary a rich harvest of information about the separate components becomes available, i.e.,

(*a*) the inclination, i, being known from the photometric solution, the orbital semi-axes, a_1 and a_2, may be determined from the spectrographic values of $a_1 \sin i$ and $a_2 \sin i$;

(*b*) thus, in turn, the sum of the masses may be computed, and, from the mass ratio, the individual masses;

(*c*) the stellar radii being known (in terms of the total orbital semi-axis, $a_1 + a_2$) from the photometric solution, and $a_1 + a_2$ being known from the spectrographic solutions, the stellar radii may be computed in absolute units;

(*d*) if the spectral type of the brighter component is known (and thus an effective temperature may be assigned) and if the ratio of the luminosities of the two components is known from the photometric solution, then it is possible, by an application of the Stefan-Boltzmann theorem, to compute values of the effective temperature (and thus spectral type) of the fainter component, and to assign the bolometric absolute magnitudes of both components.

For the two of these systems which show double lines, namely V805 Aql and V451 Oph, we have used our results along with those of the photometric solutions to obtain the data referred to above. These are given in Table VII in which the subscripts 1 and 2 refer to the brighter and fainter components respectively, and the symbols have the following meanings: m is the mass of the star; r is the radius;

TABLE VII

Physical Data for the Component Stars

	V805 Aql	V451 Oph
m_1	1.85 ⊙	2.38 ⊙
m_2	1.50 ⊙	1.98 ⊙
r_1	2.16 ⊙	2.51 ⊙
r_2	1.84 ⊙	2.01 ⊙
$sp._1$ (obs.)	A2	A0
T_{e_1}	9800°K	10700°K
$sp._2$ (comp.)	A7	A2
T_{e_2}	8000°K	9800°K
$M_{bol\ 1}$	+0.6	−0.1
$M_{bol\ 2}$	+1.8	+0.8
M_1	+1.2	+0.5
M_2	+2.2	+1.3

sp. is the spectral type, observed for the brighter component, computed for the fainter; T_e is the effective temperature either appropriate to the observed type or computed from the Stefan-Boltzmann theorem in the manner described by Plaut (1953); M_{bol} is the bolometric absolute magnitude computed in the manner of Plaut (1953); M is the "reduced" bolometric magnitude given by $M = M_{bol} + 2 \log (T_e/5200)$ which has been used by Petrie (1950) and Plaut (1953) in their discussions of the mass-luminosity relation.

When plotted on either Petrie's (1950) or Plaut's (1953) mass-luminosity diagram, the four values of mass and reduced bolometric magnitude lie close to the median of the points.

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We wish to thank Dr. A. Fresa of the Osservatorio di Capodimonte, Naples, Italy, for helpful correspondence and discussions relating to the photometric solutions of these stars. We had also been indebted to the late Professor A. Colacevich for similar kindness.

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REFERENCES

Bakos, G. 1950, *Leiden Ann.*, vol. 20, p. 177.

Colacevich, A. 1953, *Mem. S. A. It.*, vol. 24, p. 123 = *Contr. Oss. Astr. di Capodimonte*, ser. 2, vol. 4, no. 12.

Fresa, A. 1954, *Mem. S. A. It.*, vol. 23, p. 231 = *Contr. Oss. Astr. di Capodimonte*, ser. 2, vol. 4, no. 13.

Fresa, A. 1956, *Mem. S. A. It.*, vol. 27, p. 187 = *Contr. Oss. Astr. di Capodimonte*, ser. 2, vol. 4, no. 17.

Heard, J. F. and MacRae, D. A. 1957, *J. R. A. S. Canada*, vol. 51, p. 29.

Heard, J. F. and Morton, D. C. 1956, *A. J.*, vol. 61, p. 179.

Hoffmeister, C. 1935, *A. N.*, vol. 255, p. 413.

I. A. U. 1951, "47th Name-List of Variable Stars".

Petrie, R. M. 1950, *Pub. D. A. O.*, vol. 8, p. 319.

Plaut, L. 1953, *Pub. Kapteyn Astr. Lab.*, no. 55.

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THE SPECTROGRAPHIC ORBIT OF BIDELMAN'S PECULIAR STAR H.D. 30353

JOHN F. HEARD

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THE SPECTROGRAPHIC ORBIT OF BIDELMAN'S PECULIAR STAR H.D. 30353

By John F. Heard

Abstract

Orbital elements of this single-lined, hydrogen-poor spectrographic binary were published in abstract form by Heard and Boshko (1955). Since then additional observations have been obtained, and a more rigorous solution of the orbit has been made by the present writer. Velocity observations from other observatories are discussed as possible evidence of variations of the orbital elements. Photometric observations are presented which indicate that the system is not eclipsing, although a high orbital inclination might have been expected from the very large mass function. Indirect evidence that the system is very massive is adduced from the elements.

Introduction

The star H.D. 30353, $\alpha(1900)$ 4^h $41^m.8$, $\delta(1900)+43°06'$, m_{pg} 8.3, sp. Ape, has been studied by Bidelman (1950) who discussed its very peculiar spectrum and who discovered its binary character.

On the basis of the lines of ionized metals the star's spectrum resembles that of an A5 supergiant, but it shows extremely weak hydrogen lines and, at the same time, strong helium lines and numerous lines which do not appear in normal stellar spectra. Bidelman concluded that the star is truly deficient in hydrogen, and attributed the richness of the spectrum to the low opacity resulting from the hydrogen deficiency. He compared the star to several others which exhibit similar spectral peculiarities.

Bidelman's 18 published radial-velocity measures from spectrograms extending from October 1946 to April 1949 suggested a period of about one year. The range of velocities, namely about 100 km./sec., combined with the one-year period indicated a large mass function—at least 3 solar masses.

From an extensive analysis of the very rich spectrum Bidelman was able to select only eight lines which he believed were sufficiently free of blending to be trustworthy for velocity measures at moderate dispersions. These were λλ 3951.97 (V II), 4028.33 (Ti II), 4067.05 Ni II, 4101.74 (Hδ), 4122.64 (Fe II), 4233.20 (Fe II + Cr II), 4246.83 (Sc II) and 4481.23 (Mg II). He found no evidence of lines which could be attributed to the companion star.

Observations and Orbital Elements

The star was placed on the observing programme here in 1951 in the hope that the determination of definitive orbital elements would shed more light on the nature of the system and the component stars. Between 1951 and 1956 61 one-prism spectrograms of measurable quality were obtained—17 with a dispersion of 33 A./mm. at Hγ, the rest with a dispersion of 66 A./mm. The measurements for velocity were made with the use only of the lines chosen by Bidelman as listed above. On most of the plates either seven or all eight of the lines were measured, and the internal probable error of the mean velocity from a spectrogram was about 3 km./sec. on the average. In weighting the velocities for the least-squares solution for the orbital elements, weight 4 was assigned to the 33 A./mm. observations compared with weight 1 for the 66 A./mm. observations.

It is these 61 Dunlap observations of 1951–56 which form the basis of the orbital solution reported here. The period turned out to be so close to a year that there was an interval of about eighty days in the velocity curve without observations. However, in 1962 two new observations were made which fall in the middle of this gap. These observations were not incorporated in the solution, but are shown in the velocity curve of figure 1 along with the earlier Dunlap observations.

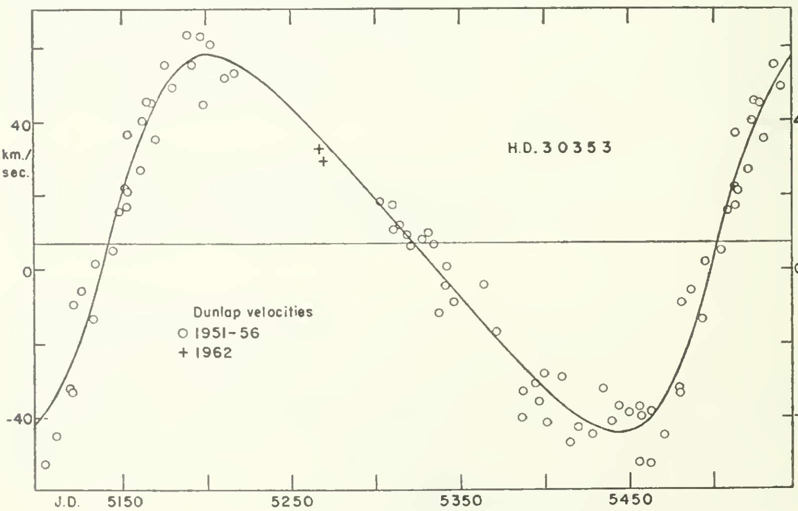

Figure 1

A preliminary orbit was derived by the use of R. K. Young's pre-computed curves, and then a least-squares solution was carried out by the digital computer method reported by Heard and MacRae (1956). The period was included in the solution, and there was no grouping of the observations. Table I gives the preliminary and final elements so derived, and Table II gives the Dunlap observations from which the solution was made plus the two 1962 observations not used in the solution.

TABLE I

ORBITAL ELEMENTS FOR H.D. 30353

Element		Preliminary	Final	m.e.
Period	P	360.00 days	360.47 days	±1.07
Eccentricity	e	0.30	0.28	±0.03
Angle of periastron	ω	270°.0	268°.4	±4.8
Periastron passage	T	J.D.2435142.80	J.D.2435141.74	±5.06
Velocity of the system	γ	+6.0 km./sec.	+7.0 km./sec.	±1.0
Semi-amplitude	K	50.0 km./sec.	51.4 km./sec.	±1.6
$a \sin i$			2.43×10^8 km.	$\pm0.08\times10^8$
Mass function	$f(m)$		4.41 ⊙	±0.44

TABLE II

DUNLAP RADIAL VELOCITY OBSERVATIONS OF H.D. 30353

J.D.	Disp. A./mm.	V_o km./sec.	Phase from final T	V_c km./sec.	$V_o - V_c$ km./sec.
2433945.787	66	−40.1	245.922	−26.1	−14.0
955.825	"	−36.0	255.960	−30.7	− 5.3
960.754	"	−41.3	260.889	−33.2	− 8.1
2434086.541	"	+44.6	26.206	+42.7	+ 1.9
260.806	33	+ 0.8	200.471	− 2.6	+ 3.4
347.597	"	−44.5	287.262	−42.3	− 2.2
375.557	"	−52.0	315.222	−43.2	− 8.8
398.538	"	−32.1	338.203	−27.3	− 4.8
412.610	66	−13.5	352.275	− 8.1	− 5.4
426.506	"	+15.9	5.701	+14.6	+ 1.3
432.596	"	+21.0	11.791	+23.3	− 2.3
443.591	"	+45.2	22.786	+38.9	+ 6.3
454.522	"	+55.1	33.716	+49.3	+ 5.8
467.567	"	+63.3	46.762	+56.0	+ 7.3
470.562	"	+55.2	49.757	+56.9	− 1.7
475.556	"	+63.1	54.751	+57.7	+ 5.4
482.565	"	+60.4	61.760	+58.0	+ 2.4
489.566	"	+51.1	68.761	+57.3	− 6.2
589.862	"	+11.0	169.057	+13.9	− 2.9
592.888	"	+12.3	172.083	+12.3	0.0

TABLE II (*continued*)

J.D.	Disp. A./mm.	V_o km./sec.	Phase from final T	V_c km./sec.	$V_o - V_c$ km./sec.
2434600.894	66	+ 6.3	180.089	+ 8.1	− 1.8
606.899	"	+ 8.1	186.094	+ 5.0	+ 3.1
613.893	"	+ 6.9	193.088	+ 1.3	+ 5.6
620.891	"	− 4.4	200.086	− 2.8	− 1.6
626.899	33	− 8.9	206.904	− 5.5	− 3.4
642.913	66	− 4.1	222.108	−13.9	+ 9.8
666.907	33	−33.1	246.102	−26.0	− 7.1
699.709	66	−43.0	278.904	−41.6	− 1.4
713.688	"	−32.3	292.883	−43.8	+11.5
735.657	"	−37.1	314.852	−43.3	+ 6.2
742.590	"	−52.3	321.785	−40.6	−11.7
750.579	"	−44.6	329.774	−35.1	− 9.5
791.490	"	+17.0	10.215	+21.8	− 4.8
793.502	"	+36.2	12.227	+24.5	+11.7
800.506	"	+25.0	19.231	+34.6	− 9.6
810.505	"	+34.7	29.230	+45.6	−10.9
819.566	"	+48.9	38.291	+52.2	− 3.3
838.540	"	+44.4	57.265	+57.9	−13.5
856.565	"	+52.7	75.290	+56.1	− 3.4
942.852	"	+18.4	161.577	+17.8	+ 0.6
949.853	33	+17.5	168.578	+14.1	+ 3.4
957.875	"	+ 9.4	176.600	+ 9.8	− 0.4
970.868	"	+ 9.8	189.593	+ 3.1	+ 6.7
977.892	66	−11.9	196.617	− 0.6	−11.3
2435009.879	"	−17.1	228.604	−17.2	+ 0.1
033.920	"	−31.0	252.645	−29.1	− 1.9
039.945	"	−28.1	258.670	−31.9	+ 3.8
050.822	"	−28.9	269.547	−36.6	+ 7.7
055.823	"	−46.8	274.548	−38.4	− 8.4
083.785	33	−36.7	302.510	−44.8	+ 8.1
089.717	"	−38.5	308.442	−44.6	+ 6.1
121.578	66	− 8.7	340.303	−24.9	+16.2
126.774	"	− 5.5	345.499	−18.2	+12.7
135.578	"	+ 1.9	354.303	− 4.9	+ 6.8
143.662	"	+ 5.2	1.917	+ 7.2	− 2.0
151.665	33	+22.0	9.920	+21.4	+ 0.6
162.655	"	+40.2	20.910	+36.7	+ 3.5
440.808	"	−41.1	299.063	−44.7	+ 3.6
457.686	"	−39.7	315.941	−43.0	+ 3.3
463.565	"	−38.5	321.820	−40.4	+ 1.9
480.676	"	−33.4	338.931	−26.5	− 6.9
2437789.581	66	+32.7	124.551	+37.0	− 4.3
791.594	"	+29.6	126.564	+35.8	− 6.2

Velocity Observations from other Observatories

Bidelman's 18 published velocity observations of 1946–49 cannot be reconciled with the Dunlap observations as well as might be expected. The question is: can the discordances be construed as evidence of changes in the orbit?

The velocities published by Bidelman (1950) were obtained from McDonald spectrograms of the years 1946 to 1949; they include one prism spectrogram ($f/2$) with dispersion 76 A./mm., three prism spectrograms (CG) with dispersion 27 A./mm. and 14 prism spectrograms (CQ) with dispersion 55 A./mm. (all dispersions at Hγ). The manner in which they disagree with the Dunlap velocity curve is seen in figure 2 where they are plotted, along with eleven unpublished velocities, kindly supplied by Bidelman, derived from McDonald CQ spectrograms taken in 1949 and 1950 in the season immediately following his published series. It will be observed that Bidelman's 1946–50 velocities, regardless of dispersion, have this pattern relative to the Dunlap velocity curve: they are systematically more negative by about 20 km./sec. over the greater part of the velocity curve, but agree with the Dunlap curve (in fact tend to be a little above it) in the middle of the steep rising branch.

It is apparent that no adjustment of the period will reconcile the two sets of observations; neither will a steady change of any of the orbital elements. Rather, it would appear that either there was a seasonal effect in the McDonald or the Dunlap velocity system (the period being so close to one year), or there was an abrupt change in the apparent orbital elements between the end of Bidelman's series in February 1950 and our series beginning in October 1951.

A single Mount Wilson Coudé spectrogram of December 22, 1950, taken by Greenstein and measured by Bidelman, falls close to the Dunlap velocity curve. So also do three velocities from McDonald Coudé spectrograms (dispersion 35 A./mm.) of December 1955, kindly taken and measured by A. Blaauw at the writer's request.

All 15 of the unpublished velocities are listed in Table III with the kind permission of the investigators involved. Along with the earlier 18 velocities published by Bidelman they are also shown plotted with reference to the Dunlap velocity curve in figure 2.

In correspondence with the writer, Bidelman has pointed out that, while he would expect his Oct. 31, 1946 velocity (from an $f/2$ spectrogram with dispersion 76 A./mm.) to be poor, a re-examination of his measures of the CG and CQ series and a survey of the velocities of

TABLE III

Unpublished Velocities of H.D. 30353

Observatory and Spectrograph		Date (U.T.)	Vel. (km./sec.)
Mt. W. Coudé (4.5 A./mm.)	1950	Dec. 22.244	−48
McD. Coudé (35 A./mm.)	1955	Dec. 4.423	−43.2
		Dec. 7.468	−36.6
		Dec. 8.429	−40.8
McD. CQ (55 A./mm.)	1949	Sept. 12.344	−13.8
		Sept. 12.364	−13.1
		Sept. 12.386	−18.9
		Sept. 12.405	−17.4
		Dec. 4.275	−58.9
		Dec. 11.264	−52.6
		Dec. 19.324	−65.3
		Dec. 22.132	−64.7
	1950	Jan. 5.267	−54.8
		Feb. 2.094	−25.8
		Feb. 24.075	+ 3.5

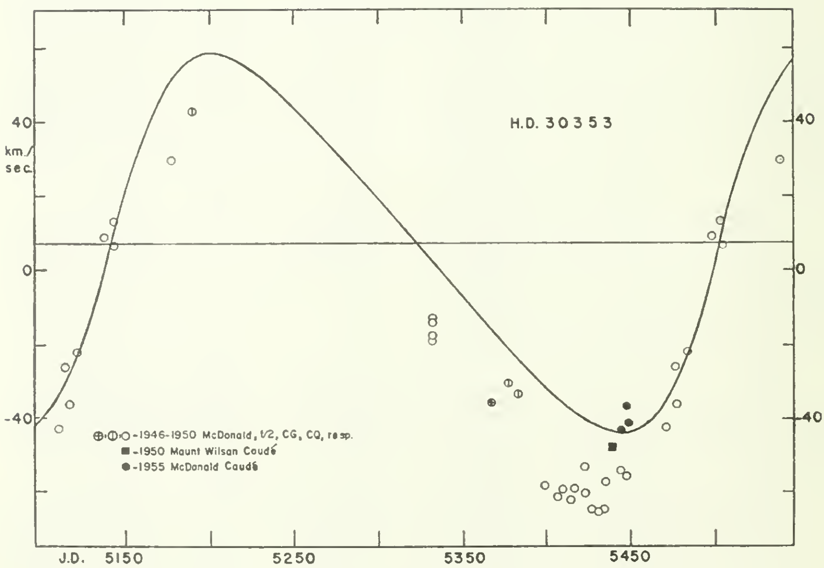

Figure 2

standard velocity stars taken during the long "run" of McDonald CQ spectrograms of 1948–49 have convinced him that there are no large systematic or seasonal errors in his velocities. On the other hand, the present writer has a similar conviction regarding the Dunlap velocities, and draws attention again to the agreement of the 1955 McDonald Coudé velocities and the 1950 Mount Wilson Coudé velocity with the Dunlap velocities. Furthermore, each of us, using the same lines, fails to find systematic velocity differences which could be attributed to effects of blending with different dispersions, and, indeed, our dispersions are not dissimilar (McDonald 27 and 55 A./mm., Dunlap 33 and 66 A./mm.).

If, as it would thus appear, we may rule out what might have seemed to be systematic errors of either or both of the McDonald and Dunlap velocity systems, we are left with the conclusion that there occurred between early 1950 and late 1951, if not a change in the elements, at least some effect which mimicked such a change.

Photometric Observations

The large mass function of 4.4$\odot$ for H.D. 30353 brought up the interesting possibility of this binary being an eclipsing system. In Moore's (1948) *Fifth Catalogue of Spectroscopic Binaries* there are seven binaries with listed mass functions greater than 3$\odot$; all seven are eclipsing systems. Since there is no evidence whatever of a secondary component of H.D. 30353 in the spectrum, one might expect the eclipse of the primary star, if it occurs, to be deeper than that of the secondary. From the orbital elements the times of superior conjunction of the primary were calculated to be about August 4, 1955 and July 29, 1956, with mean error of about 5 days. Because of the long period the eclipse, if any, might be expected to last for some days. With the possibility of detecting an eclipse, G. A. Bakos, then at this Observatory, undertook to make photoelectric observations of H.D. 30353, using the 19-inch reflecting telescope. The observations at the time of superior conjunction of the primary were made difficult by reason of the large easterly hour angle of the star at dawn; it will be noticed that this difficulty has been aggravated from year to year. It will not be convenient to observe the star again at superior conjunction for some years to come. An inferior conjunction, corresponding to possible eclipse of the secondary, would have occurred about Jan. 31, 1956.

From the observations which Bakos was able to obtain in 1955 and 1956 there is no evidence of an eclipse. His observations near superior conjunctions were on 1955 Aug. 8, 16, and 24, and on 1956 July 28, 29, 31, Aug. 8, 14, 22, and 25; and near inferior conjunction he had observations on 1956 Jan. 17 and Feb. 10. No minima were detected at these times. Also it should be remarked that a study of our spectrograms revealed no evidence of an atmospheric eclipse near the times of conjunctions of the primary.

Although Bakos' observations revealed no eclipses, they did indicate variability of the light. Altogether, between Aug. 8, 1955 and Nov. 8, 1956, he obtained photoelectric observations, mostly in two colours, on 57 nights. Variations amounting to about 0.1 magnitude were detected. There is an indication that the variations may consist of short-lived increases in brightness about every 30 days.

The Masses of the Components

Bidelman (1950) has remarked on one consequence of the large mass function of H.D. 30353, namely that it indicates a fairly massive secondary. Table IV indicates a few possible combinations of the masses of primary and secondary which are consistent with our mass function of 4.4$\odot$ for inclinations of 90° and of 45°.

TABLE IV

Possible Mass Combinations and Deviations from the Mass-Luminosity Law

	For $i = 90°$		For $i = 45°$	
Mass of observed component	Mass of unobserved component	Mag. dev.	Mass of unobserved component	Mag. dev.
2$\odot$	7$\odot$	7^m	15$\odot$	10^m
10	13	3	25	6
20	19	2	33	4

If the mass-luminosity law is given by $\Delta M = 9.54 \log m_2/m_1$, and if the secondary is at least two magnitudes fainter than the primary (since the secondary's spectrum is not seen), then the figures designated by "Mag. dev." in Table IV are the least number of magnitudes by which the stars would fail to be related by the mass-luminosity law, in the sense of the observed component being over-luminous. It is seen that the departure would be rather spectacular if the primary is a dwarf, and would amount to several magnitudes even if the primary has the mass of a supergiant.

The absolute magnitude of the primary is not known with certainty, but Bidelman (1950) has remarked on the fact that the spectrum resembles that of a supergiant, and he calculated that if the difference between the measured colour index of 0.54 and an assumed normal colour index of 0.10 can be attributed to interstellar reddening, then the primary would be a rather luminous supergiant ($M = -6$, say). If this is the case he would expect the mass of the primary to be of the order of 20$\odot$, and we would then be dealing with a very massive pair. Bidelman noted that these are mere speculations, however, since, for all we know, a star with such a peculiar spectrum may be very over-luminous for its mass and it may be intrinsically reddened.

Since Bidelman (1950) wrote the foregoing discussion of the reddening, Hiltner (1956) has published three-colour and polarization observations of H.D. 30353. From Hiltner's data we may compute that the absorption in the visual is at least $0^m.83$, and that $(B-V)_0 \leqslant 0^m.18$, and $(U-B)_0 \leqslant -0^m.37$, and we should note that the weakness of the hydrogen lines will be expected to make the star bright in the ultra-violet because of the smallness of the Balmer jump. To draw further conclusions, however, would require a precise spectral classification—which we do not have.

ACKNOWLEDGEMENTS

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REFERENCES

Bidelman, W. P. 1950, *Ap. J.*, vol. 111, p. 333.
Heard, J. F. and Boshko, O. 1955, *A. J.*, vol. 60, p. 162.
Heard, J. F. and MacRae, D. A. 1957, *J.R.A.S. Canada*, vol. 51, p. 29.
Hiltner, W. A. 1956, *Ap. J. Supp.*, vol. 2, no. 24, p. 389.
Moore, J. H. and Neubauer, F. J. 1948, *L.O.B.*, no. 521.

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PHOTOELECTRIC SPECTROPHOTOMETRY OF GLOBULAR CLUSTERS

SIDNEY VAN DEN BERGH
AND
R. C. HENRY

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PHOTOELECTRIC SPECTROPHOTOMETRY OF GLOBULAR CLUSTERS

By Sidney van den Bergh and R. C. Henry

Abstract

A spectrum scanner attached to the 74-inch telescope has been used to derive absolute energy distributions over the range λλ3400 to 5200 for the following globular clusters:

NGC 5024 (M53)	NGC 6273 (M19)	NGC 6838 (M71)
NGC 5272 (M3)	NGC 6341 (M92)	NGC 6864 (M75)
NGC 5904 (M5)	NGC 6356	NGC 6934
NGC 6093 (M80)	NGC 6402 (M14)	NGC 7006
NGC 6205 (M13)	NGC 6626 (M28)	NGC 7078 (M15)
NGC 6229	NGC 6656 (M22)	NGC 7089 (M2)
NGC 6254 (M10)	NGC 6779 (M56)	NGC 7099 (M30)

An effective resolution of about 35A. was used for all globular-cluster observations. For comparison purposes the nuclei of the galaxies M31 and M32 and a number of MK standard stars were also observed with the same resolution.

Certain combinations of monochromatic colour indices are found to yield reddening-free parameters which correlate well with Morgan's metallic line strength classification of globular clusters. A discontinuity in the spectral energy distribution near λ4000 is found to correlate with metallic line strength in globular clusters and with metal abundance in main sequence stars. Colour-colour diagrams may be constructed which permit a clear-cut segregation of the effects of interstellar reddening from those of intrinsic colour differences. Observations of M31 show that cyanogen giants provide a major contribution to the total luminosity of the nucleus in blue light.

Introduction

The properties of the integrated light of globular clusters have been studied on low dispersion spectra by Mayall (1946), Morgan (1956, 1959) and Kinman (1959). These investigations have established that globular clusters exhibit a considerable range in spectroscopic characteristics, which may be partially interpreted in terms of differences between the metal abundances of stars in different clusters. Three-colour observations of globular clusters in the galaxy have recently been published by Johnson (1959) and by Kron and Mayall (1960).

It is the purpose of the present investigation to help fill the gap between the very-low-resolution, wide-band photometry and the higher-resolution spectroscopic work. In particular multi-colour narrow-band photometry should be able to separate the effects of interstellar reddening from intrinsic colour effects. This does not appear to be possible using the wide-band *UBV* and *PVI* systems. Spectral scanning with intermediate resolution also holds promise of being able to measure some of the qualitative differences between globular clusters which have previously been found by visual inspection of cluster spectra.

Instrumentation and Observing Technique

The observations reported in this paper were made with a spectrum scanner designed by J. B. Oke, which is located at the Cassegrain focus of the 74-inch telescope. The light enters the instrument through an entrance diaphragm, which, in the present observing programme, was 4.6 mm. in diameter, corresponding to 28 seconds of arc on the sky. The collimator in the scanner matches the $f/18$ beam of the telescope and has a focal length of 36 inches. The dispersing element is a Bausch and Lomb replica reflection grating with 600 grooves per millimetre. The centre of its blaze is at λ3750 in the second order, which was the order used. A Newtonian "camera" with a focal length of 9 inches forms an image on an adjustable Hilger spectrograph slit. During the globular cluster observations a slit width of 0.56 millimetres was used, which corresponds to 18.5 A.

Immediately behind the slit is a quartz Fabry lens which has a focal length of 1.4 inches. A selected RCA 1P21 photomultiplier, which was refrigerated by dry ice, was used as a light detector. The output of the photomultiplier was fed to a General Radio 1230 amplifier and recorded by a Brown recorder. During the observations a scanning speed of 4 A./sec. was used, giving a dispersion of 4.65 A./mm. on the tracing. A time constant of 2.5 seconds was employed for all the globular cluster observations. The effective resolution (spectral purity) resulting from the time constant, entrance diaphragm size and exit slit width was about 35A., the exact value depending slightly on the degree of central concentration of light in the globular cluster image.

A single observation consisted of a direct scan from λλ5200 to 3400 and a reverse scan from λλ3400 to 5200 followed, for bright clusters, by a single direct scan of the sky. For those faint clusters, for which the cluster plus sky deflection was less than two or three times larger than the sky reading, a direct and a reverse sky trace were obtained. Due to the proximity of the city of Toronto to the David Dunlap Observatory the sky background at low altitudes is primarily a function of azimuth. For clusters observed at low altitudes the sky tracings were therefore obtained at the same altitude and azimuth as the cluster tracings. The instrumental arrangement did not permit guiding during the 8 minutes required to make a single scan. For clusters observed near the meridian no serious difficulties due to driving errors, resulting in drifting of the cluster image, were encountered.

Determination of the Atmospheric Absorption

The following early-type stars, for which Oke (1960) has determined the absolute energy distributions, were used to determine both the atmospheric extinction and the instrumental sensitivity function:

ξ^2 Cet B9 III	α CrB A0 V
γ Gem A0 IV	α Lyr A0 V
α Leo A B7 V	

The wave-length dependence of the atmospheric extinction was determined by measurements of the same star at high and low altitudes at 12 wave-lengths in the range $3500 \leqslant \lambda \leqslant 5150$ A. (The star α CrB, which is an eclipsing variable, was not observed at or near times of eclipse.)

TABLE I

The Observed Atmospheric Extinction

λ	λ^{-4} (μ)	$K(\lambda)-A$	m.e.
5150	14.22	$0^m.186$	$\pm$ $0^m.024$
5000	16.00	0.204	0.020
4700	20.49	0.227	0.012
4500	24.39	0.256	0.020
4200	32.14	0.358	0.016
4040	37.54	0.412	0.020
3920	42.35	0.461	0.024
3860	45.05	0.474	0.027
3815	47.21	0.471	0.023
3700	53.36	0.593	0.025
3600	59.54	0.684	0.022
3500	66.64	0.743	0.028

It was found that, within the accuracy of the observations, the data for each night could be adequately represented by an equation of the form:

$$K(\lambda) = A + B\,\lambda^{-4}, \tag{1}$$

in which K is the absorption (in magnitudes) for one air mass and A a grey term which varies from night to night. The mean values of $K(\lambda) - A$, from 14 extinction observations on 10 nights, are given in Table I and plotted in figure 1. With λ measured in microns a

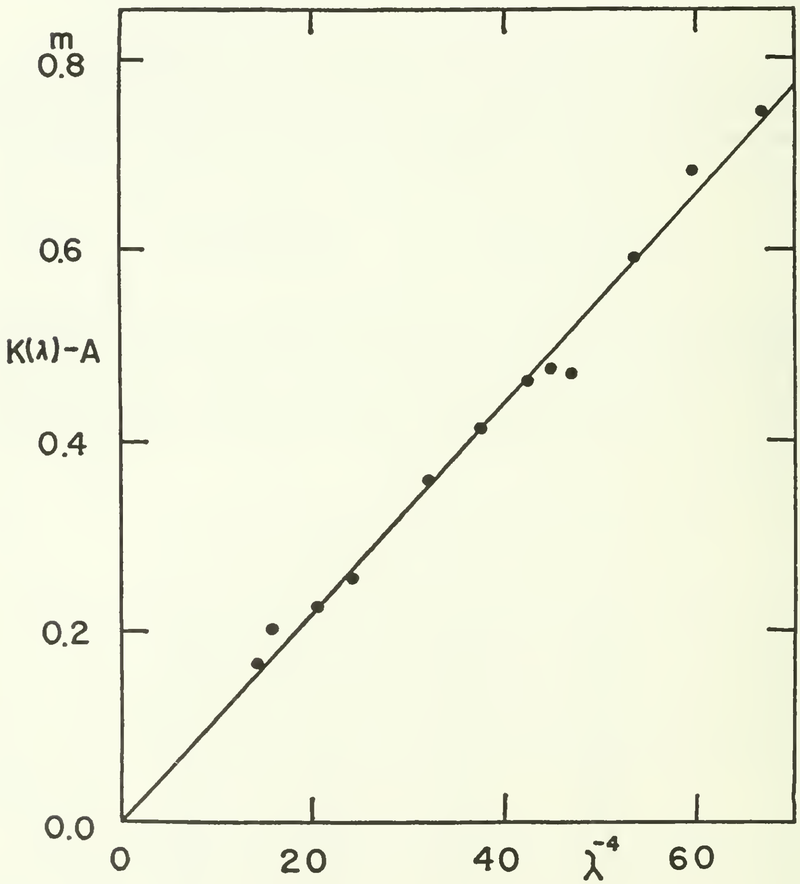

FIG. 1—Wave-length dependence of the atmospheric absorption, with grey term subtracted. The figure shows that the observed absorption may be adequately represented by a λ^{-4} law.

least-squares solution yields the following mean value for the coefficient B in equation (1):

$$\bar{B} = 0.01085 \pm 0.00021;$$

this may be compared with the value

$$\bar{B} = 0.01077 \pm 0.00017,$$

which Greig (1962) has derived from observations on 12 nights by Bless (1958) at Michigan. (Both Observatories are located at about the same altitude above sea level.)

The value $B = 0.01085$ was subsequently used for all nights. Actually changes in the atmospheric pressure will result in slight variations of B from night to night. Use of the mean value of B will therefore result in random errors, which are, however, judged to be small compared to the observational uncertainty of the determination of B from observations obtained during a single night. Furthermore not all nights produced a measure of the extinction because on some nights clouds appeared before a second observation of an extinction star could be obtained.

Absorption in the blue and violet region of the spectrum was found to be larger than average on nights during which observations were made through hot moist tropical air. Such nights were characterized by a very red setting sun, a "light" night sky and often by unusually good seeing. Tracings obtained on such nights were not used to derive absolute energy distributions.

The Instrumental Sensitivity Function

The observing equipment does not give an identical response when illuminated with equal intensities of light of different wave-lengths. This is due to the wave-length dependence of the reflectivity of the mirrors in the light path and the wave-length dependence of the response of the 1P21 photomultiplier. The instrumental sensitivity function may be determined by comparing the observed spectral energy distribution of Oke's standard stars corrected to outside the atmosphere by means of equation (1), with the absolute energy distributions of these stars which have been published by Oke (1960).

On the average two standard star observations were obtained each night. Usually all individual sensitivity functions obtained during one dark-run were combined into a single mean sensitivity function, which was then used to reduce all the globular cluster observations obtained during that period.

In deriving the instrumental sensitivity function from observations of Oke's standard stars difficulties were encountered in the region between λλ3700 and 3900. Over this wave-length range the Balmer lines are crowded so close together that limited wave-length resolution, seeing and the amplifier and pen-recorded time constants all tend to lower the observed continuum. In this region Oke therefore recommends the use of a pseudo-continuum drawn through the peaks at a breadth of 12 A. In our experience this procedure did not yield reproducible results. Since the instrumental sensitivity function changes only slowly with wave-length over this region, a simple interpolation procedure was used. It is believed that the sensitivity function obtained in this way is correct to within $0\overset{m}{.}02$ at all wave-lengths in the range $3700 < \lambda < 3900$ A.

Extensive data are available on the changes in the instrumental sensitivity function during the period from May 1961 to May 1962 (the mirrors of the 74-inch telescope were re-aluminized in May 1962). Table II summarizes the available data for this period on $\delta\,\dot{S}(\lambda)$, defined as the rate of change of the sensitivity function in magnitudes per year, relative to the rate of change of the sensitivity function at λ4500. The data in Table II, which are plotted in figure 2, show that the instrumental sensitivity function changes most rapidly in the ultraviolet. Over the range λλ3500 to 5200 the rate of change

TABLE II

Observed Relative Change of Instrumental Sensitivity Function in Magnitudes per Year

λ	$\delta\,\dot{S}(\lambda)$
5150	$-0\overset{m}{.}123$
5000	−0.088
4700	−0.026
4500	−0.007
4200	+0.055
4040	+0.076
3700	+0.143
3600	+0.167
3500	+0.190

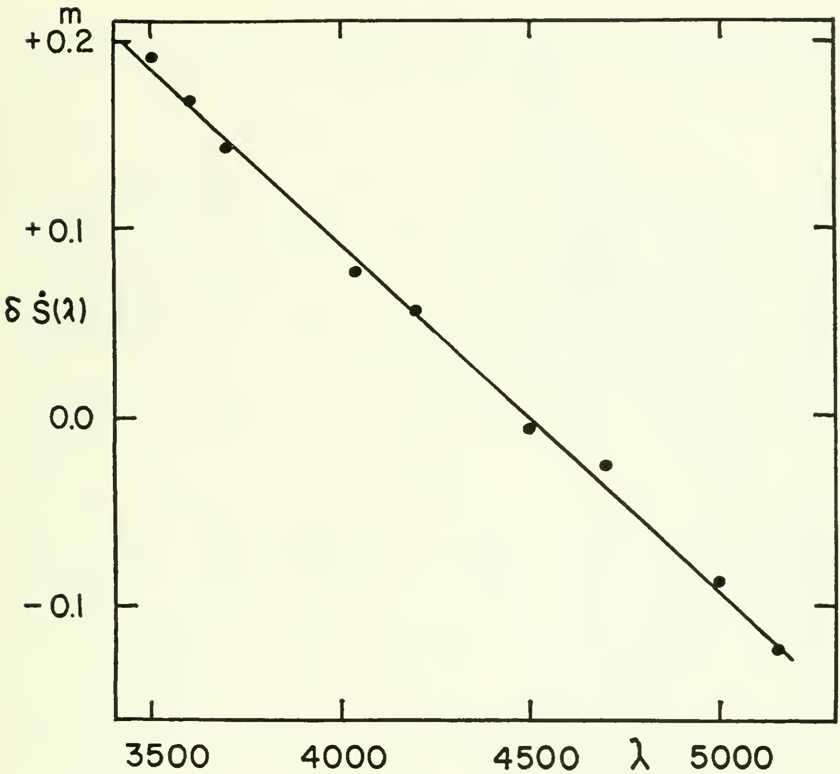

FIG. 2—Rate of change of the instrumental sensitivity function in magnitudes per year, normalized to zero at λ4500. The rapid decrease of the instrumental sensitivity at short wave-lengths is due to the deterioration of the ultraviolet reflectivity of the mirrors in the light path.

of the sensitivity function in magnitudes per year, at any wave-length relative to that at λ4500 is given by

$$\delta\dot{S}(\lambda) = 1.85 \times 10^{-4}\,(4500-\lambda). \qquad (2)$$

The fact that the instrumental sensitivity decreases fastest at short wave-lengths is no doubt due to the rapid deterioration of the ultraviolet reflectivity of aluminized reflecting surfaces.

Young (1962) has shown that the spectral response of 1P21 photomultipliers is slightly dependent on temperature. To reduce such temperature-dependent variations of the photomultiplier sensitivity

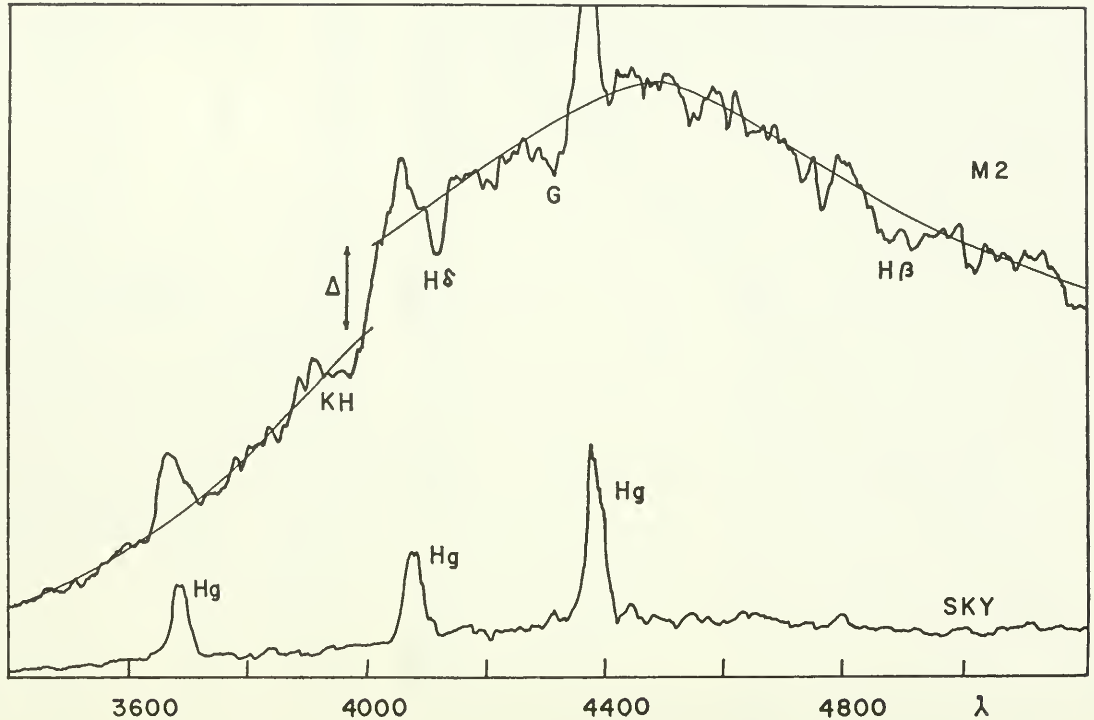

Fig. 3—Tracing of the globular cluster M2 with sky tracing superimposed. The adopted pseudo-continuum is indicated by the smooth curve.

to a minimum, dry ice was introduced into the cold-box surrounding the 1P21 about one hour before the beginning of the actual observations.

Reduction of the Observations

Figure 3 shows a typical globular cluster tracing with a sky tracing superimposed. The irregular line represents the actually-observed spectral-energy distribution and the smooth curve shows the adopted pseudo-continuum. Except in the regions near Hβ, Hδ, the *G*-band and the MgI triplet $\lambda\lambda$5167–84 the adopted pseudo-continuum represents the smoothed mean of the actually-observed spectral-energy distribution. Attention should be drawn to the apparent discontinuity in the pseudo-continuum near λ4000; just to the red of the $H+$ Hϵ blend. The size of this discontinuity expressed in magnitudes, will be denoted by the symbol Δ.

On each tracing the height of the pseudo-continuum and of the sky background was measured at 100-A. intervals. The intensity difference between sky, and object plus sky, was then converted to a magnitude scale with arbitrary zero point. These magnitudes were then corrected for atmospheric extinction and for the instrumental sensitivity function to yield the absolute energy distribution $m(1/\lambda)$ at 100-A. intervals. The absolute energy distributions of the same cluster obtained on different nights, each of which contains an arbitrary zero point, were plotted on transparent graph paper and fitted together by visual inspection. The resulting mean absolute energy distributions, normalized to $m(1/\lambda) = 0.0$ at λ4500, are given in Table III. A minimum of three tracings on good photometric nights were averaged to obtain the adopted mean absolute energy distribution of a single cluster. (The average number of tracings per cluster was 5.) Also given in Table III are the spectral energy distributions of the galaxies M31 and M32 and of the MK standard stars ρ Gem (F0 V), βCVn (G0 V) and 61 UMa (G8 V).

The fact that so many globular clusters occur in the general direction of the galactic nucleus necessitated observations down to rather large negative declinations. Many of the clusters contained in the present programme had to be observed through more than two air masses. However, no observations were made at sec $z \geqslant 3.0$. The fact that so many clusters had to be observed at large values of sec z placed very severe demands on the photometric quality of the nights on which

TABLE III

Absolute Energy Distributions of Globular Clusters, Galaxies, and Standard Stars

	NGC 221 (M32)		NGC 224 (M31)		NGC 5024 (M53)	
	n = 6		n = 7		n = 8	
λ	m(1/λ)	m.e.	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	−0.32	± 0.01	−0.29	± 0.01	−0.30	± 0.02
5100	−0.32	0.01	−0.28	0.01	−0.28	0.01
5000	−0.29	0.01	−0.28	0.01	−0.23	0.01
4900	−0.25	0.01	−0.24	0.01	−0.17	0.01
4800	−0.21	0.01	−0.19	0.01	−0.13	0.01
4700	−0.16	0.01	−0.14	0.01	−0.10	0.01
4600	−0.09	0.01	−0.09	0.01	−0.05	0.01
4500	0.00	0.01	0.00	0.01	0.00	0.01
4400	0.17	0.01	0.20	0.01	0.09	0.01
4300	0.36	0.01	0.42	0.01	0.20	0.01
4200	0.53	0.01	0.62	0.01	0.29	0.02
4100	0.65	0.02	0.75	0.01	0.34	0.02
4000	0.75	0.02	0.82	0.02	0.38	0.03
3900	1.34	0.02	1.57	0.02	0.65	0.04
3800	1.40	0.03	1.65	0.03	0.75	0.04
3700	1.42	0.03	1.66	0.03	0.96	0.06
3600	1.61	0.03	1.79	0.04	1.01	0.08
3500	1.72	0.04	1.89	0.05	1.06	0.09
3400	1.63	0.05	1.89	0.07	1.36	0.12

	NGC 5272 (M3)		NGC 5904 (M5)		NGC 6093 (M80)	
	n = 6		n = 5		n = 3	
λ	m(1/λ)	m.e.	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	—	—	−0.30	± 0.02	−0.37	± 0.01
5100	−0.27	± 0.02	−0.29	0.01	−0.33	0.01
5000	−0.22	0.01	−0.26	0.01	−0.26	0.01
4900	−0.18	0.01	−0.21	0.01	−0.20	0.01
4800	−0.12	0.01	−0.16	0.01	−0.14	0.01
4700	−0.11	0.01	−0.13	0.01	−0.11	0.01
4600	−0.07	0.01	−0.08	0.01	−0.06	0.01
4500	0.00	0.01	0.00	0.01	0.00	0.01
4400	0.09	0.01	0.07	0.01	0.12	0.02
4300	0.19	0.01	0.19	0.01	0.24	0.02
4200	0.28	0.01	0.28	0.01	0.33	0.02
4100	0.36	0.01	0.35	0.01	0.43	0.02
4000	0.39	0.02	0.40	0.01	0.52	0.03
3900	0.66	0.02	0.74	0.02	0.82	0.03
3800	0.74	0.02	0.84	0.02	0.91	0.04
3700	0.91	0.02	0.97	0.02	1.11	0.05
3600	1.07	0.03	1.16	0.03	—	—
3500	1.22	0.04	1.26	0.05	—	—
3400	—	—	1.52	0.07	—	—

TABLE III (*Continued*)

	NGC 6205 (M13)		NGC 6229 —		NGC 6254 (M10)	
	n = 7		n = 5		n = 4	
λ	m(1/λ)	m.e.	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	−0.29	± 0.02	−0.33	± 0.02	−0.44	± 0.06
5100	−0.30	0.02	−0.33	0.02	−0.38	0.04
5000	−0.26	0.01	−0.28	0.01	−0.31	0.03
4900	−0.21	0.01	−0.23	0.01	−0.21	0.03
4800	−0.17	0.01	−0.18	0.01	−0.17	0.02
4700	−0.13	0.01	−0.14	0.01	−0.14	0.02
4600	−0.07	0.01	−0.08	0.01	−0.08	0.02
4500	0.00	0.01	0.00	0.01	0.00	0.02
4400	0.10	0.01	0.10	0.01	0.17	0.02
4300	0.20	0.01	0.23	0.01	0.29	0.02
4200	0.29	0.02	0.33	0.01	0.38	0.02
4100	0.36	0.02	0.43	0.01	0.44	0.02
4000	0.43	0.02	0.52	0.02	0.50	0.03
3900	0.72	0.02	0.82	0.02	0.86	0.04
3800	0.78	0.03	0.89	0.02	0.98	0.05
3700	0.98	0.03	0.99	0.02	1.22	0.07
3600	1.10	0.04	1.20	0.02	1.27	0.09
3500	1.25	0.04	1.31	0.03	—	—
3400	1.42	0.05	1.48	0.03	—	—

	NGC 6273 (M19)		NGC 6341 (M92)		NGC 6356 —	
	n = 4		n = 6		n = 4	
λ	m(1/λ)	m.e.	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	−0.50	± 0.02	−0.30	± 0.02	−0.52	± 0.02
5100	−0.42	0.02	−0.29	0.02	−0.46	0.02
5000	−0.32	0.02	−0.24	0.01	−0.40	0.02
4900	−0.23	0.02	−0.18	0.01	−0.33	0.01
4800	−0.16	0.02	−0.14	0.01	−0.26	0.01
4700	−0.13	0.02	−0.11	0.01	−0.21	0.01
4600	−0.07	0.02	−0.05	0.01	−0.10	0.02
4500	0.00	0.02	0.00	0.01	0.00	0.02
4400	0.11	0.02	0.08	0.01	0.17	0.02
4300	0.26	0.03	0.16	0.01	0.36	0.03
4200	0.41	0.03	0.23	0.01	0.53	0.03
4100	0.50	0.04	0.32	0.01	0.68	0.04
4000	0.55	0.05	0.40	0.02	0.76	0.05
3900	0.98	0.06	0.58	0.02	1.34	0.06
3800	1.07	0.08	0.72	0.02	1.42	0.10
3700	1.20	0.13	0.88	0.03	1.58	0.12
3600	—	—	1.05	0.04	—	—
3500	—	—	1.20	0.04	—	—
3400	—	—	1.39	0.07	—	—

TABLE III (*Continued*)

λ	NGC 6402 (M14)		NGC 6626 (M28)		NGC 6656 (M22)	
	n = 5		n = 5		n = 4	
	m(1/λ)	m.e.	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	−0.67	± 0.01	−0.51	± 0.03	−0.49	± 0.03
5100	−0.56	0.01	−0.44	0.02	−0.45	0.03
5000	−0.44	0.01	−0.36	0.02	−0.37	0.02
4900	−0.33	0.01	−0.28	0.02	−0.27	0.02
4800	−0.25	0.01	−0.22	0.01	−0.22	0.02
4700	−0.18	0.01	−0.18	0.01	−0.19	0.02
4600	−0.10	0.01	−0.11	0.01	−0.10	0.02
4500	0.00	0.01	0.00	0.01	0.00	0.02
4400	0.12	0.01	0.16	0.01	0.08	0.02
4300	0.31	0.01	0.36	0.01	0.21	0.02
4200	0.44	0.02	0.50	0.02	0.33	0.03
4100	0.56	0.02	0.61	0.02	0.38	0.03
4000	0.67	0.03	0.75	0.03	0.38	0.04
3900	1.08	0.04	1.16	0.06	0.80	0.05
3800	—	—	—	—	0.90	0.06
3700	—	—	—	—	1.00	0.09
3600	—	—	—	—	*N.B.*—Brightest cluster stars avoided.	
3500	—	—	—	—		
3400	—	—	—	—		

λ	NGC 6779 (M56)		NGC 6838 (M71)		NGC 6865 (M75)	
	n = 5		n = 6		n = 5	
	m(1/λ)	m.e.	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	−0.46	± 0.02	−0.48	± 0.02	−0.38	± 0.03
5100	−0.41	0.02	−0.46	0.02	−0.35	0.02
5000	−0.32	0.02	−0.39	0.01	−0.32	0.02
4900	−0.25	0.01	−0.32	0.01	−0.26	0.02
4800	−0.19	0.01	−0.25	0.01	−0.22	0.01
4700	−0.15	0.01	−0.20	0.01	−0.15	0.02
4600	−0.08	0.01	−0.15	0.01	−0.07	0.02
4500	0.00	0.01	0.00	0.02	0.00	0.02
4400	0.10	0.02	0.19	0.02	0.14	0.02
4300	0.21	0.02	0.40	0.02	0.26	0.02
4200	0.30	0.02	0.53	0.02	0.35	0.03
4100	0.41	0.02	0.63	0.03	0.44	0.03
4000	0.49	0.03	0.69	0.04	0.47	0.04
3900	0.74	0.03	1.34	0.05	0.96	0.05
3800	0.88	0.04	1.30	0.08	1.10	0.06
3700	1.10	0.06	1.36	0.13	1.16	0.10
3600	1.33	0.07	—	—	—	—
3500	1.48	0.10	—	—	—	—
3400	—	—	—	—	—	—

TABLE III (*Continued*)

	NGC 6934 —		NGC 7006 —		NGC 7078 (M15)	
	n = 4		n = 4		n = 5	
λ	m(1/λ)	m.e.	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	−0.38	± 0.02	−0.34	± 0.02	−0.29	± 0.02
5100	−0.33	0.02	−0.28	0.02	−0.29	0.02
5000	−0.27	0.02	−0.23	0.02	−0.24	0.01
4900	−0.22	0.02	−0.17	0.02	−0.17	0.01
4800	−0.17	0.01	−0.13	0.02	−0.14	0.01
4700	−0.12	0.01	−0.09	0.02	−0.11	0.01
4600	−0.07	0.01	−0.05	0.02	−0.06	0.01
4500	0.00	0.01	0.00	0.02	0.00	0.01
4400	0.10	0.02	0.08	0.02	0.07	0.01
4300	0.22	0.02	0.19	0.02	0.16	0.01
4200	0.32	0.02	0.26	0.02	0.25	0.01
4100	0.41	0.02	0.34	0.02	0.32	0.01
4000	0.50	0.02	0.41	0.03	0.38	0.01
3900	0.82	0.02	0.75	0.03	0.61	0.01
3800	0.91	0.03	0.80	0.03	0.72	0.01
3700	1.05	0.03	0.91	0.04	0.90	0.02
3600	1.34	0.05	1.08	0.05	1.09	0.02
3500	—	—	1.20	0.08	1.18	0.03
3400	—	—	1.29	0.16	1.30	0.05

	NGC 7089 (M2)		NGC 7099 (M30)	
	n = 5		n = 6	
λ	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	−0.29	± 0.04	−0.28	± 0.03
5100	−0.26	0.02	−0.23	0.02
5000	−0.21	0.02	−0.17	0.02
4900	−0.17	0.02	−0.13	0.02
4800	−0.14	0.01	−0.10	0.02
4700	−0.11	0.01	−0.08	0.01
4600	−0.07	0.01	−0.04	0.01
4500	0.00	0.01	0.00	0.02
4400	0.10	0.01	0.08	0.02
4300	0.19	0.01	0.18	0.02
4200	0.26	0.01	0.25	0.02
4100	0.33	0.01	0.33	0.02
4000	0.39	0.01	0.40	0.02
3900	0.70	0.01	0.62	0.02
3800	0.78	0.02	0.78	0.03
3700	0.95	0.02	0.96	0.04
3600	1.13	0.02	—	—
3500	1.19	0.03	—	—
3400	1.28	0.05	—	—

TABLE III (*Continued*)

	ρ Gem F0 V		β CVn G0 V		61 UMa G8 V	
	n = 4		n = 4		n = 4	
λ	m(1/λ)	m.e.	m(1/λ)	m.e.	m(1/λ)	m.e.
5200	−0.03	± 0.01	−0.20	± 0.01	−0.24	± 0.01
5100	−0.07	0.01	−0.19	0.01	−0.24	0.01
5000	−0.04	0.01	−0.16	0.01	−0.20	0.01
4900	−0.02	0.01	−0.13	0.01	−0.18	0.01
4800	−0.02	0.01	−0.12	0.01	−0.15	0.01
4700	−0.04	0.01	−0.08	0.01	−0.12	0.01
4600	−0.02	0.01	−0.06	0.01	−0.08	0.01
4500	0.00	0.01	0.00	0.01	0.00	0.01
4400	0.04	0.01	0.11	0.01	0.15	0.01
4300	0.07	0.01	0.20	0.01	0.28	0.01
4200	0.12	0.01	0.29	0.01	0.39	0.01
4100	0.17	0.01	0.37	0.01	0.49	0.01
4000	0.22	0.01	0.44	0.01	0.58	0.01
3900	0.48	0.01	0.84	0.01	1.10	0.01
3800	0.63	0.01	0.88	0.01	1.15	0.01
3700	0.93	0.01	0.92	0.01	1.19	0.01
3600	1.05	0.01	1.03	0.01	1.28	0.01
3500	1.15	0.01	1.14	0.02	1.40	0.01
3400	1.24	0.02	1.27	0.02	1.49	0.02

observations were made. In fact many tracings had to be rejected because observations of standard stars showed that some nights were not of the highest photometric quality. Other reasons for rejecting tracings were moderate or strong auroral activity, cloud danger to individual tracings and occasional instrumental difficulties. In the final analysis about one third of all tracings obtained had to be rejected for one of the reasons listed above.

Inspection of Table III shows that absolute energy distributions could not be obtained for all clusters to the extreme short wave-length limit of λ3400. This was due to the fact that, for globular cluster observations, the difference between total brightness and sky brightness is much smaller in the ultraviolet than it is in the blue-green region of the spectrum. In no cases were differences of less than 0.5 inches between total signal and sky background measured on the tracings.

Inspection of the sample tracing illustrated in figure 3 shows that three wave-length regions, with a width of about 50 A. each, are completely obscured by mercury emission lines of terrestrial origin. Our experience indicates that these lines introduce very little uncertainty in the interpolated position of the pseudo-continuum. In fact these lines were found to furnish convenient wave-length standards for the measurement of the tracings of faint globular clusters. The N_2^+ emission band near λ3900, which occurs with variable strength during weak aurorae, proved much more bothersome and frequently introduced considerable uncertainty in the measurements of the discontinuity Δ near λ4000.

Observational Errors

The mean errors of the absolute energy distribution of globular clusters at each wave-length were estimated from the scatter of the individual observations about the mean. Figure 4 shows a plot of the

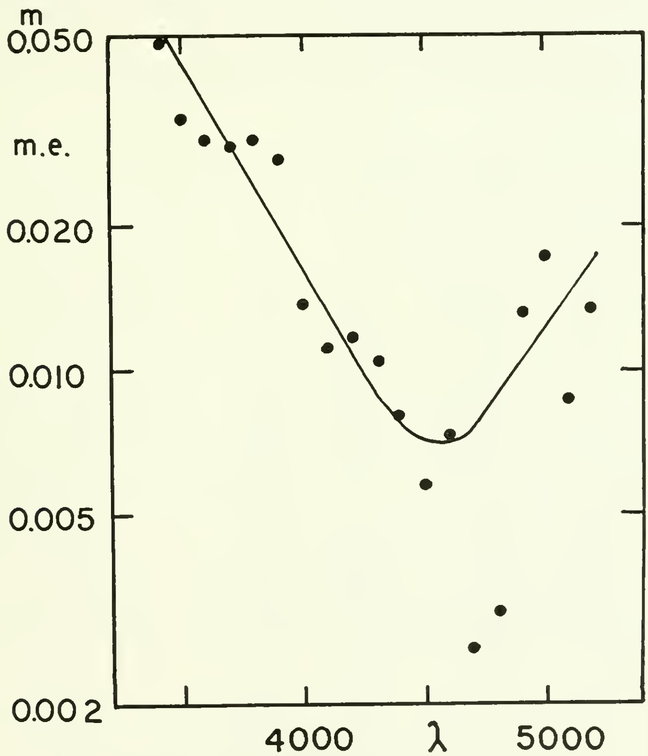

Fig. 4—Wave-length dependence of the observational errors of the absolute energy distribution of M92. The smooth curve shows the adopted wave-length dependence of the errors, the dots the observed errors at each wave-length.

observed mean error of $m(1/\lambda)$ at each wave-length obtained for M92. The smooth curve in the figure represents the adopted mean error at each wave-length. Comparison of figures 3 and 4 shows that the observational errors are smallest at those wave-lengths at which the observed brightness of globular clusters is greatest. The fact that the extinction corrections are largest in the far ultraviolet probably contributes to the relatively large errors at short wave-lengths. (For sec z = 2.5 the extinction correction is 1.66 magnitudes larger at λ3400 than it is at λ5200.) The temperature sensitivity of photomultipliers in the yellow (Young 1962) and the uncertainty of the adopted pseudo-continuum level due to the Mg I triplet λλ5167–84 may contribute to the increase of the observational uncertainties longward of λ5000.

To ensure adequate wave-length resolution the size of the entrance diaphragm of the spectrophotometer had to be rather small. The 28″ diaphragm which was used during all globular cluster observations admitted only a small fraction of the total cluster light. The P magni-

TABLE IV

Comparison of P–V and C(41–51)

NGC	M	P_{28}	P–V	A.D.	n	C(41–51)	m.e.	n
5024	53	11.2	0.50	0.00	2	0.63	0.03	8
5272	3	10.1	0.56	0.04	3	0.63	0.02	6
5904	5	10.2	0.63	0.01	4	0.64	0.01	5
6093	80	10.1	0.76	0.02	4	0.76	0.02	3
6205	13	10.7	0.57	0.02	6	0.66	0.02	7
6229	—	11.6	0.64	0.01	2	0.76	0.02	5
6254	10	12.0	0.79	0.01	3	0.82	0.04	4
6273	19	11.2	0.90	0.03	4	0.91	0.05	4
6341	92	9.7	0.53	0.00	2	0.61	0.02	6
6356	—	12.0	1.06	0.02	3	1.13	0.04	4
6402	14	12.9	1.12	0.04	5	1.12	0.02	5
6626	28	—	0.97	0.02	3	1.05	0.03	5
6656	22	11.4	0.86	0.01	2	(0.83)	0.04	4
6779	56	12.8	0.74	0.04	3	0.82	0.03	5
6838	71	13.1	0.95	0.01	2	1.10	0.04	6
6864	75	10.6	0.71	0.00	2	0.79	0.04	5
6934	—	11.4	0.62	0.01	3	0.75	0.02	4
7006	—	12.6	0.61	0.01	2	0.62	0.03	4
7078	15	9.2	0.59	0.01	2	0.61	0.02	5
7089	2	10.1	0.57	0.01	2	0.59	0.03	5
7099	30	10.6	0.48	0.00	2	0.56	0.03	6

tudes of a region with a diameter of 28″ centred on the cluster were extrapolated from data given by Kron and Mayall and are given under the column heading P_{28} in Table IV. The table shows that P_{28} ranges from $9^{m}.2$ for the brightest observed cluster to $13^{m}.1$ for the faintest cluster. The 18.5 A. width of the exit slit reduces the effective brightness of the cluster, which is seen by the photomultiplier, by an additional factor of about 4 magnitudes compared to that which would be observed in wide-band photometry. The resulting weakness of the observed signal undoubtedly contributes significantly to the observational errors for the faintest globular clusters.

The determination of the absolute energy distribution of each globular cluster was based on observations during at least two dark runs. Errors in the determination of the sensitivity function for any one dark run will therefore manifest themselves by an increase in the scatter of the individual absolute energy distributions about the mean. Since only one observation of a given globular cluster was obtained on any one night, deviations of the nightly absorption coefficients from the adopted mean absorption coefficient will also show up as scatter of the individual spectral energy distributions about the mean. It is therefore believed that the mean errors of the absolute energy distribution derived from the scatter of the individual observations which are quoted in Table III, represents a realistic appraisal of the actual accuracy of the results. Any errors in the adopted absolute energy distribution of the primary standard star α Lyrae will of course be reflected in the results.

An additional check on the accuracy of the data may be obtained from intercomparison of the spectral energy distributions of high latitude, and hence presumably little reddened, clusters which according to Kron and Mayall have the same spectral type and which have been assigned to the same metallic line class by Morgan. Such clusters would be expected to have closely similar spectral energy distributions. Figure 5 shows such a comparison for the high latitude clusters M2 and M53. The figure shows that within the accuracy of the data, the absolute spectral energy distributions of these two clusters are identical.

Comparison with Wide-Band Photometry

Observations of a number of globular clusters on the *UBV* system have been published by Johnson (1959). A more extensive series of

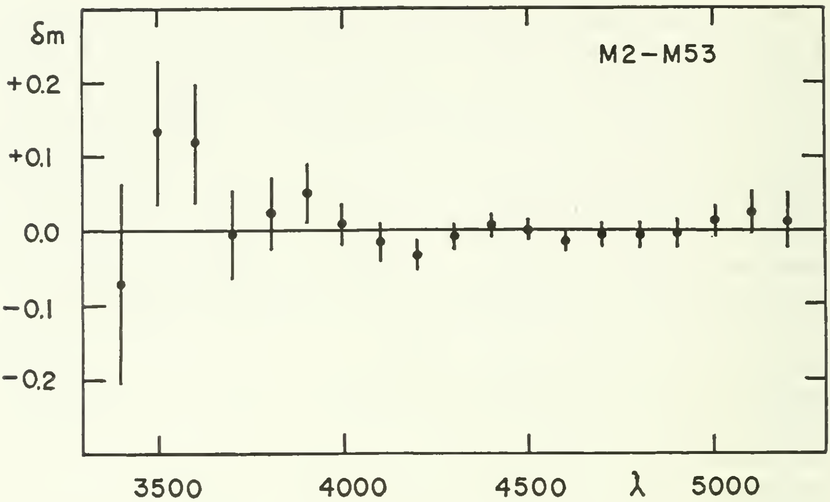

FIG. 5—Observed difference between the absolute energy distributions of the high latitude clusters M2 and M53. Both clusters have the same integrated spectral type and are assigned to the same metallic line strength group by Morgan. The length of the error bars indicates the mean error of each point. Within the accuracy of the data both clusters are seen to have the same absolute energy distribution.

observations on the *PVI* system has been reported by Kron and Mayall (1960). The latter series contains $P-V$ colour indices for all of the globular clusters for which absolute energy distributions are given in Table III.

To compare the present results with those of Kron and Mayall it is convenient to introduce monochromatic colour indices. For example, the colour index $C(41\text{–}51)$, which will be defined as the difference between $m(1/\lambda)$ at $\lambda 4100$ and $m(1/\lambda)$ at $\lambda 5100$, may be compared with $P-V$. The observational data on $P-V$ and $C(41\text{–}51)$ are listed in Table IV and plotted in figure 6. The figure shows that the data may be adequately represented by the linear relation:

$$C(41\text{–}51) = P-V + 0.07. \qquad (3)$$

The observations of the very scattered large diameter cluster M22 are not plotted in figure 6. The $P-V$ observations of this cluster presumably refer to the integrated light of the entire cluster, whereas individual bright cluster stars had to be avoided during the spectrophotometric observations.

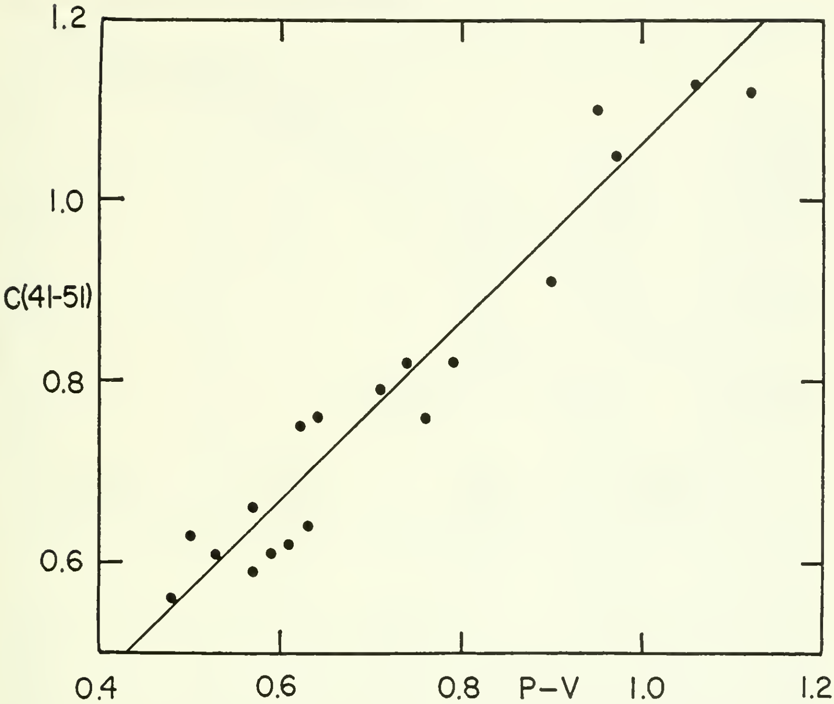

FIG. 6—Comparison of the $P-V$ colours of globular clusters with the observed monochromatic colour indices $C(41-51)$.

Within the accuracy of the data, no systematic differences exist between the $C(41-51)$ versus $P-V$ relations for clusters at high and low declinations. Since the low declination clusters were observed through a much larger air mass than the high declination clusters, this provides an additional check on the accuracy of the adopted wave-length dependence of the atmospheric extinction.

DISCUSSION OF RESULTS

Intrinsic Differences Between Clusters

The absolute energy distributions given in Table III for the relatively metal-rich cluster NGC 6356 and for the very metal-poor cluster M92 are compared in figure 7. The figure shows a number of striking differences which cannot be accounted for in terms of differences in the amount of interstellar absorption suffered by these two clusters.

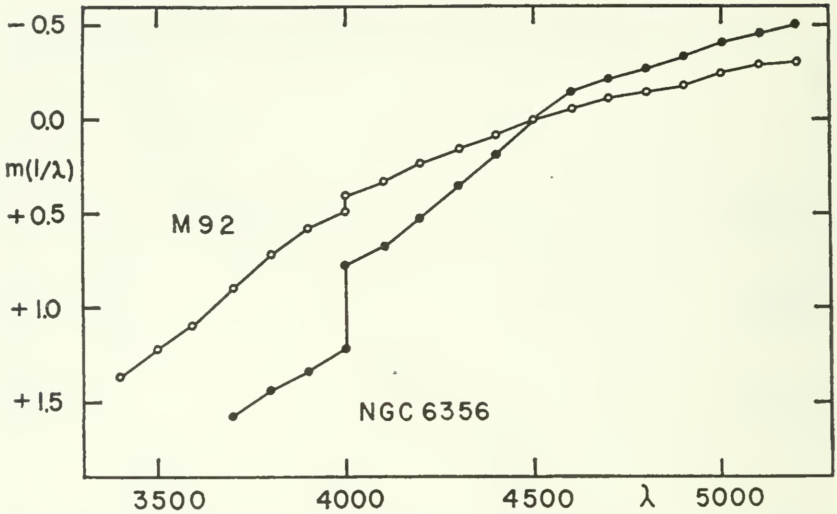

FIG. 7—Comparison of the observed absolute energy distributions of the very metal-poor cluster M92 and the relatively metal-rich cluster NGC 6356.

In the first place figure 7 shows that the discontinuity Δ of the adopted pseudo-continuum near λ4000 is very much larger in the metal-rich cluster NGC 6356 than it is in the metal-poor cluster M92. This indicates that the index Δ may be correlated with metal abundance. Inspection of the figure also shows that the slope of the pseudo-continuum of the two clusters differs much more strongly over the range λλ4100 to 4500 than it does over the range λλ4600 to 5100. This suggests that a combination of the monochromatic colour indices $C(41–45)$ and $C(46–51)$ might permit a separation of intrinsic colour effects from the effects of interstellar reddening.

Interstellar Reddening

In a colour-colour plot using either the *UBV* system (Johnson 1959) or the *PVI* system (Kron and Mayall 1960) the points corresponding to the intrinsic colours of globular clusters lie almost exactly along a reddening line. As a result *UBV* and *PVI* colour observations cannot be used to segregate intrinsic colour effects from the effects of interstellar reddening. Inspection of figure 7 suggests that a two-colour diagram, using the colour indices $C(41–45)$ versus $C(46–51)$, might be useful in separating intrinsic colour effects from interstellar

TABLE V

MONOCHROMATIC COLOUR INDICES AND PARAMETERS Φ AND Ψ

NGC	M	C(41–45)	m.e.	C(46–51)	m.e.	Φ	m.e.	Ψ	m.e.
221	32	0.65	±0.02	0.23	±0.01	0.47	±0.02	1.02	±0.03
224	31	0.75	0.02	0.19	0.01	0.60	0.02	1.29	0.02
5024	53	0.34	0.03	0.23	0.02	0.16	0.03	0.37	0.04
5272	3	0.36	0.02	0.20	0.02	0.20	0.02	0.39	0.03
5904	5	0.35	0.01	0.22	0.01	0.18	0.02	0.44	0.02
6093	80	0.43	0.03	0.27	0.02	0.22	0.03	0.49	0.04
6205	13	0.36	0.02	0.23	0.02	0.18	0.02	0.43	0.03
6229	—	0.43	0.02	0.24	0.02	0.24	0.02	0.49	0.03
6254	10	0.44	0.03	0.30	0.04	0.20	0.04	0.47	0.06
6273	19	0.50	0.05	0.35	0.03	0.22	0.05	0.57	0.07
6341	92	0.32	0.01	0.24	0.02	0.13	0.02	0.29	0.03
6356	—	0.68	0.04	0.36	0.02	0.39	0.05	0.88	0.07
6402	14	0.56	0.02	0.46	0.01	0.20	0.03	0.52	0.04
6626	28	0.61	0.03	0.33	0.02	0.35	0.03	0.72	0.07
6656	22	(0.38)	0.04	(0.35)	0.03	(0.10)	0.04	(0.35)	0.06
6779	56	0.41	0.02	0.33	0.02	0.14	0.03	0.33	0.04
6838	71	0.63	0.04	0.32	0.02	0.38	0.04	0.87	0.06
6864	75	0.44	0.04	0.28	0.03	0.22	0.04	0.61	0.06
6934	—	0.41	0.02	0.27	0.02	0.20	0.03	0.48	0.03
7006	—	0.34	0.03	0.23	0.02	0.15	0.04	0.46	0.04
7078	15	0.32	0.01	0.23	0.02	0.14	0.02	0.31	0.02
7089	2	0.33	0.01	0.19	0.03	0.18	0.03	0.44	0.03
7099	30	0.33	0.02	0.19	0.03	0.18	0.03	0.39	0.04
ρ Gem	F0 V	0.17	0.01	0.05	0.01	0.13	0.01	0.41	0.02
β CVn	G0 V	0.37	0.01	0.13	0.02	0.26	0.02	0.65	0.02
61 UMa	G8 V	0.49	0.01	0.16	0.01	0.36	0.01	0.86	0.02

reddening. These colour indices as derived from the data in Table III, are given in Table V. Figure 8 shows a plot of $C(41–45)$ versus $C(46–51)$ for those clusters for which Morgan has given metallic line strength classifications. Also shown is the reddening line derived from Whitford's (1958) reddening law. The figure shows that metal-rich clusters lie well to the right of the reddening line for metal-poor clusters. The position of a globular cluster in figure 8 may be used to estimate both the metallic line strength classification of that cluster and the reddening of that cluster relative to other clusters of the same metallic line strength. However, the total reddening of the cluster can be

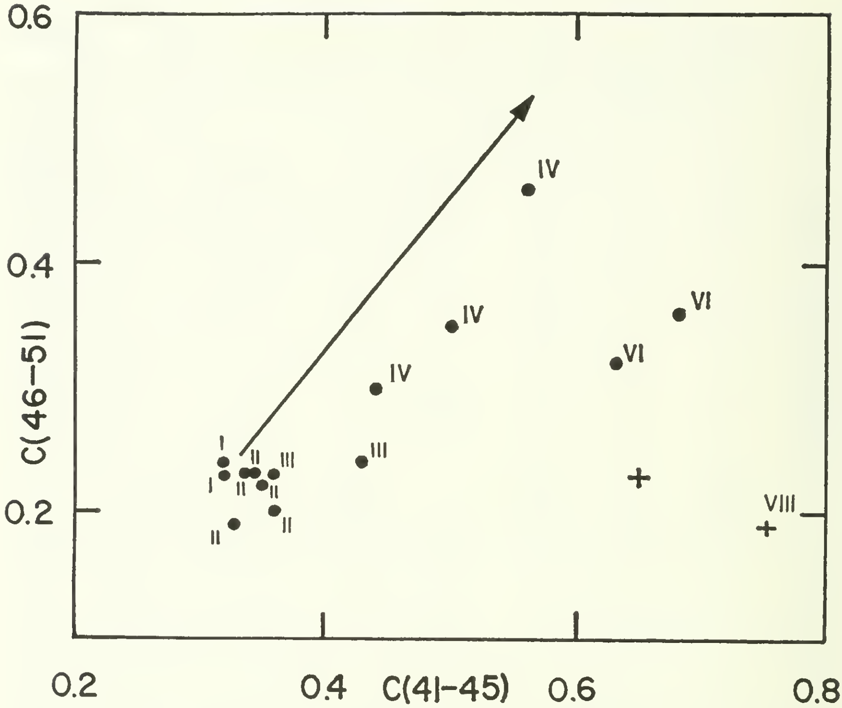

FIG. 8—Two-colour index diagram of globular clusters which have Morgan metallic line strength classifications. The reddening line for metal-poor clusters is indicated by an arrow. The figure shows a clear-cut segregation of intrinsic colour effects from the effects of interstellar reddening. The nuclei of M31 and M32 are indicated by crosses.

determined only after some *a priori* assumption is made about the intrinsic colours of clusters in a certain metallic line strength group.

The Metal Abundance Parameter Δ

The size of the discontinuity in the pseudo-continuum near λ4000 was measured directly on each globular cluster tracing (see figure 3). It should be emphasized that such measurements are quite difficult, especially for faint clusters in which the signal-to-noise ratio is small. The strong terrestrial mercury emission lines near λ4050 and the N_2^+ night sky band near λ3900 also contribute to the uncertainty of the measurements. Table VI lists the mean observed values of Δ, expressed

TABLE VI

OBSERVATIONS OF THE DISCONTINUITY Δ

NGC	M	$\bar{\Delta}$	A.D.	n	Morgan metal class
221	32	0.50	0.04	6	—
224	31	0.59	0.03	5½	VIII
5024	53	0.21	0.04	7	II
5272	3	0.20	0.04	9	II
5904	5	0.23	0.03	5	II
6093	80	0.25:	0.11	3½	—
6205	13	0.28	0.06	9	III
6229	—	0.20	0.04	6	III
6254	10	0.25:	0.09	2½	IV
6273	19	0.40	0.04	4½	IV
6341	92	0.09	0.03	9	I
6356	—	0.48	0.05	4	VI
6402	14	0.30	0.03	2½	IV
6626	28	0.26:	0.11	4½	—
6656	22	(0.31:)	0.08	3	II
6779	56	0.21	0.06	5	—
6838	71	0.52	0.08	8	VI
6864	75	0.26:	0.06	3½	—
6934	—	0.23	0.02	4½	—
7006	—	0.33	0.02	4½	II
7078	15	0.14	0.03	10	I
7089	2	0.23	0.04	5	II
7099	30	0.12	0.04	6	—

in magnitudes, for all the programme clusters. Also given are the average deviation, *A.D.*, of the individual Δ observations from the mean and the number of observations, *n*, on which this mean is based. In forming the mean, half weight was given to those Δ determinations which were considered to be of lesser accuracy; either because of small deflections on the tracings or on account of the strength of N_2^+ night sky emission. It will be seen that for some clusters the number of observations used to determine Δ was larger than the number employed to derive the absolute energy distribution of that same cluster. This is due to the fact that the index Δ could be measured on a number of tracings obtained on nights which were not of the highest photometric quality.

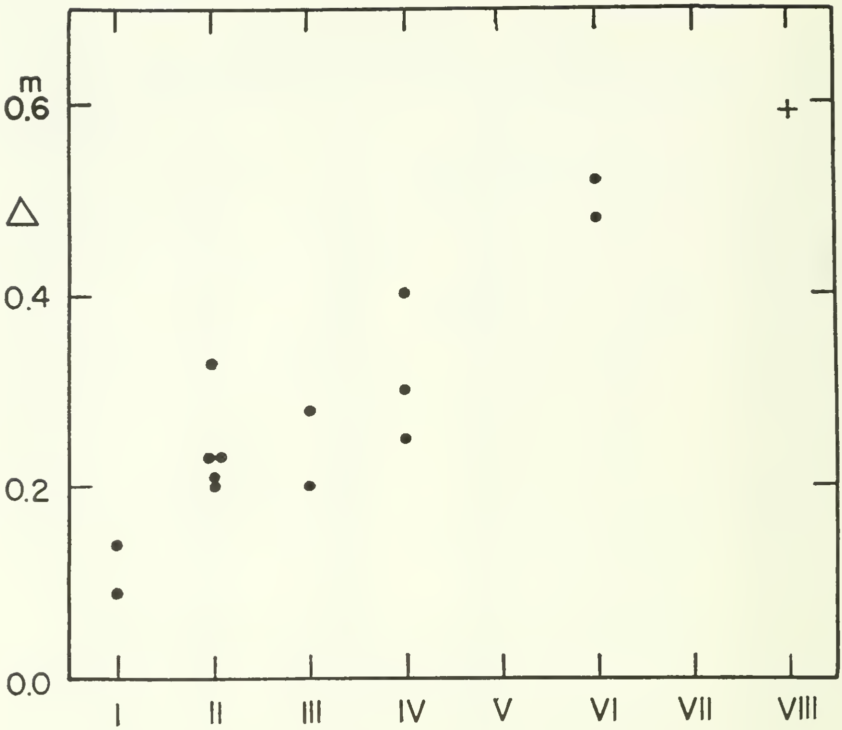

FIG. 9—Correlation between Morgan's metallic line strength classification and the discontinuity Δ near λ4000. The cross represents the nucleus of M31.

For those clusters for which this information is available the metallic line-strength classification (Morgan 1959) is also given in Table VI. Figure 9 shows that the discontinuity index Δ correlates well with Morgan's metallic line-strength classification. That such a correlation between metallic line-strength and discontinuity of the observed pseudo-continuum near λ4000 is to be expected may be seen from figure 1 of Wildey *et al.* (1962). Their figure shows that, for F- and G-type stars, the fraction of the radiant flux which is blocked by Fraunhofer lines is much larger to the blue of λ4000 than it is redward of this wave-length.

Additional confirmation of the relation between the size of the Δ index and metal abundance is provided by observations (van den Bergh, unpublished) of the Δ index in main-sequence stars of differ-

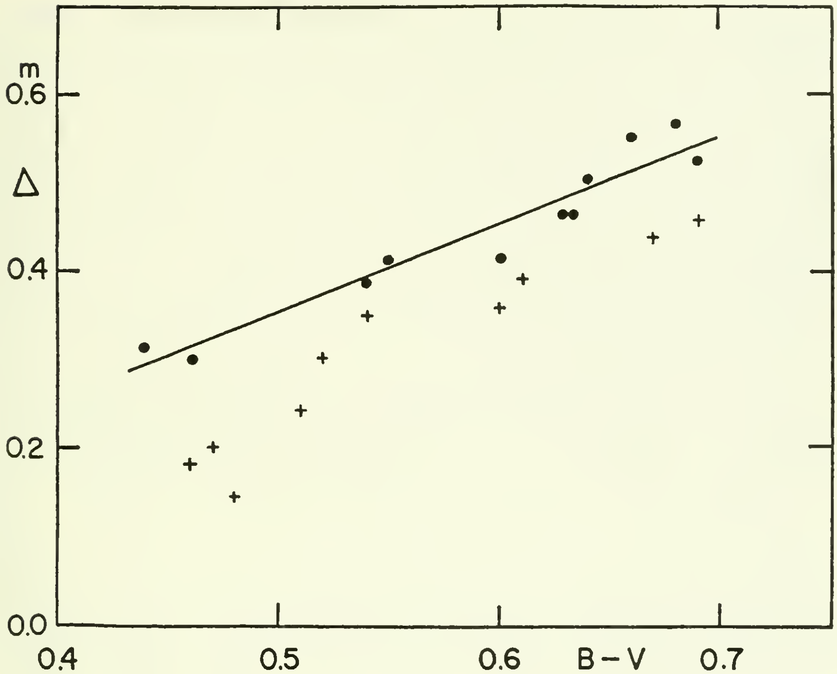

FIG. 10—The figure shows the relation between Δ and $B-V$ for main sequence stars of normal metal abundance (dots) and metal-poor stars (crosses). At a given colour the discontinuity Δ is seen to be smaller for metal-defficient stars than for stars of normal metal abundance. The mean relation for stars with normal metal abundances is indicated by a straight line.

ing metal abundances. For these measurements the effective spectral resolution was comparable to that employed during the globular cluster observations. The results of these measurements are plotted in figure 10. The figure shows that, for any $B-V$ value, stars of normal metal abundance $[\delta(U-B) < 0.06]$ have a larger Δ value than do metal-poor stars $[\delta(U-B) > 0.12]$. The smallest observed Δ value occurs for the subdwarf H.D. 140283, which is the most metal-deficient dwarf star known.

Some caution should be exercised in the interpretation of the relation between metal abundance and the quantity Δ in the nuclei of M31 and M32. For composite stellar systems the observed value of Δ will depend on both the metal abundance and the frequency

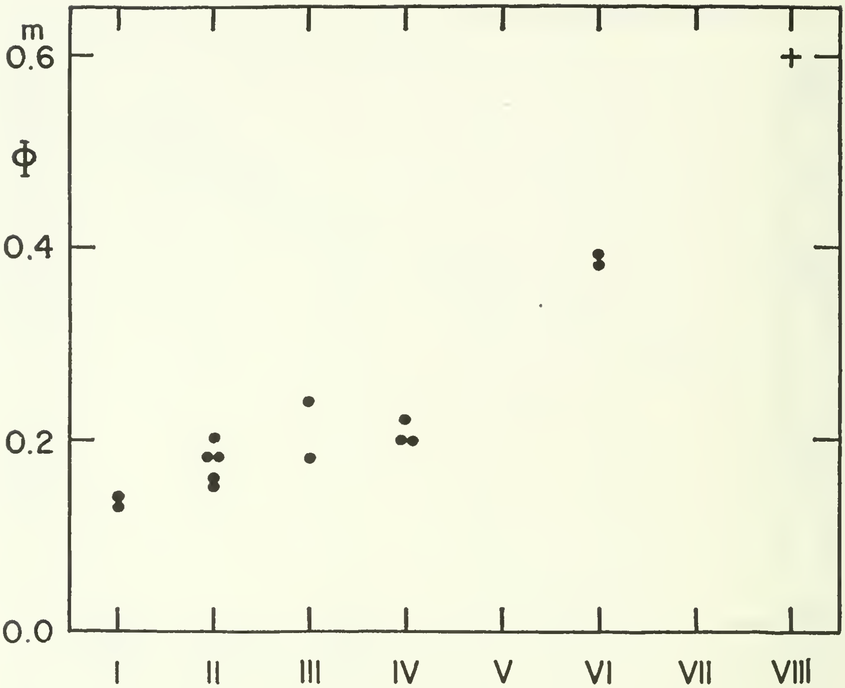

FIG. 11—Relation between the parameter Φ and Morgan's metallic line strength classification. The cross represents the nucleus of M31.

distribution of stars in different regions of the colour-magnitude diagram. For example the large value of Δ observed for the nucleus of M31 might be due either to a metal-rich stellar population or to a strong contribution of late-type stars to the total light. Also K-type giant stars have larger Δ values than do main sequence stars of the same spectral type.

Other Intrinsic Parameters of Globular Clusters

Using the wave-length dependence of interstellar reddening, which has been determined by Whitford (1958), it is possible to form combinations of monochromatic colour indices which are independent of interstellar reddening. Such reddening-free indices may be regarded as intrinsic parameters of composite stellar systems. For example one may define a quantity

$$\Phi = C(41\text{–}45) - 0.8C(46\text{–}51), \tag{4}$$

which is a function of the gradient of the absolute energy distribution to the red of the discontinuity Δ near λ4000. The Φ indices for all clusters observed during the present programme are listed in Table V. Figure 11 shows that the index Φ correlates well with Morgan's (1959) metallic line strength classification. From an observational point of view the index Φ has the advantage that it is determined in the blue-green region of the spectrum where the signal-to-sky ratio is large and where atmospheric extinction corrections are not as great as they are in the ultraviolet. Spectrophotometric observations of high- and low-velocity main sequence stars by Greig (1962) also show that combinations of monochromatic colour indices determined in the range $4100 \leqslant \lambda \leqslant 5100$ A. yield parameters which correlate with the ultraviolet excess and metal abundance of those stars.

Another reddening-free parameter, which includes the discontinuity Δ near λ4000, may be defined by

$$\Psi = C(39\text{–}45) - C(45\text{–}51). \tag{5}$$

Due to the inclusion of a measurement in the violet region of the spectrum, the errors associated with the determination of Ψ are larger than those associated with the measurement of Φ. These larger errors are, however, compensated for by the fact that among globular clusters Ψ, which includes the discontinuity Δ, exhibits a wider range of variation than does Φ. The values of Ψ derived from the observations are given in Table V. Figure 12 shows that the parameter Ψ correlates well with Morgan's metallic line strength classification.

The correlations of Δ, Φ, and Ψ with the integrated spectral types of globular clusters (Kron and Mayall 1960) show considerably more scatter than do the correlations with Morgan's metallic line strength classification. Presumably this indicates that metallic line strength is a more accurate classification parameter than is "integrated spectral type".

The fact that Δ, Φ, Ψ and metallic line strength classification all correlate well together suggests that they all measure essentially the same parameter i.e. metal abundance. This view receives support from a comparison of the spectral energy distributions of the very metal-poor cluster M92 and the relatively metal-rich cluster NGC 6356. The difference in the visual absorption suffered by these two clusters is $0^{\mathrm{m}}.7$ for Kron and Mayall's "Solution I" and $1^{\mathrm{m}}.3$ for their "Solution II". Adopting a visual absorption of $1^{\mathrm{m}}.0$ and Whitford's reddening law the difference between the true absolute energy distributions of

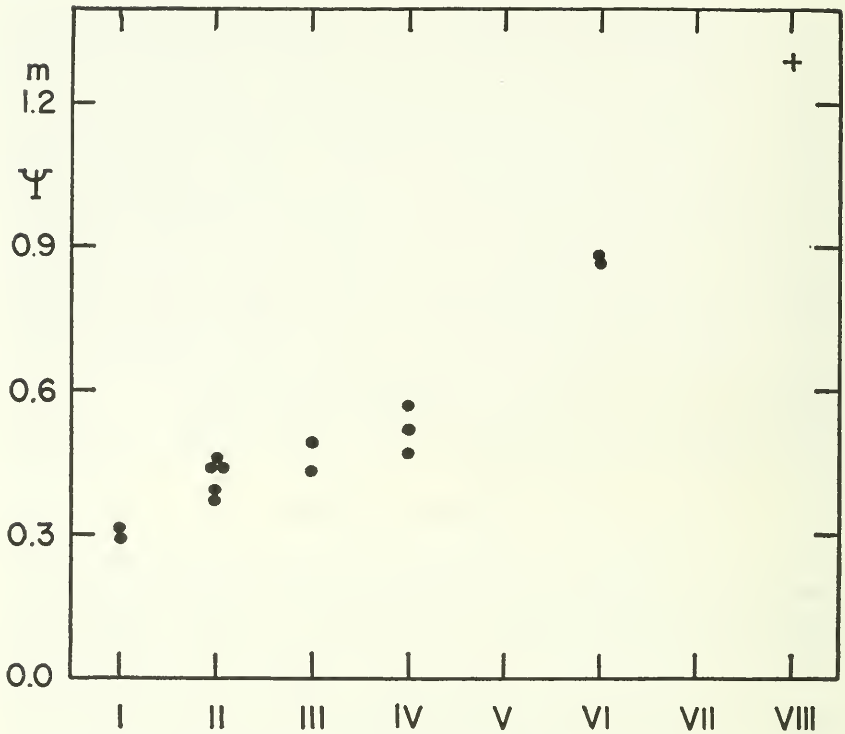

FIG. 12—Relation between the parameter Ψ and Morgan's metallic line strength classification. The cross represents the nucleus of M31.

these two clusters may be determined. The resulting differences between the absolute energy distributions of M92 and NGC 6356, normalized to zero at λ4500, are plotted in figure 13. Also shown in the figure 13 is the quantity ϵ_λ; the fraction of the total energy in the solar continuum (Michard 1950) which is blocked by Fraunhofer lines. The similarity of these two curves strongly suggests that differences between the metal abundances of the stars in M92 and NGC 6356 are largely responsible for the observed differences of the absolute energy distributions of these two clusters.

Comparison of M31 and M32 with Globular Clusters

In Table VII the indices Δ, Φ, and Ψ for the nuclei of the galaxies M31 and M32 are compared with those of the relatively metal-rich

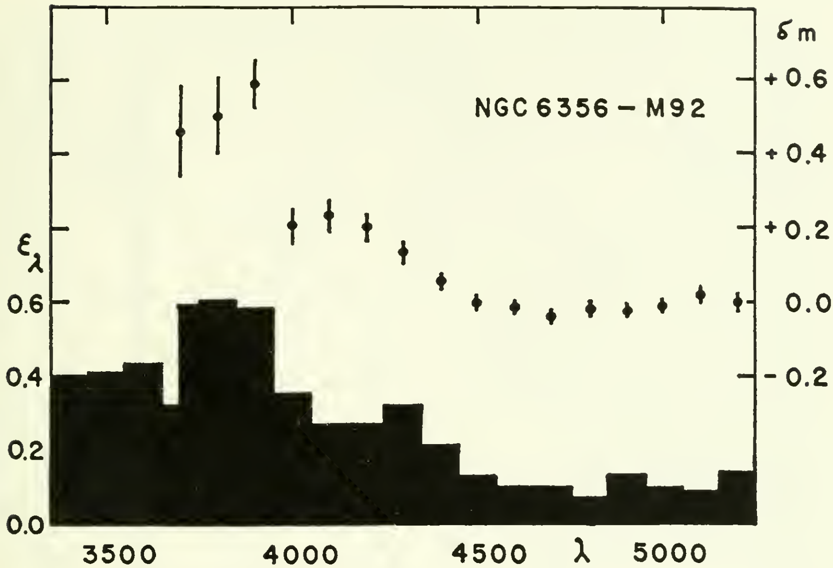

FIG. 13—Difference between the true absolute energy distributions of the relatively metal-rich cluster NGC 6356 and the very metal-poor cluster M92 under the assumption that the interstellar absorption A_v suffered by NGC 6356 is 1.0 magnitudes larger than that suffered by M92. Error bars indicate means errors of each difference. The histogram shows the fractional blocking of radiant energy by Fraunhofer lines in the sun. The similarity of the two curves suggests that the observed differences between the spectral energy distributions of the two clusters may be largely accounted for by the difference in their metal abundances.

TABLE VII

COMPARISON OF M31, M32 AND GLOBULAR CLUSTERS

	$\bar{\Delta}$	Φ	Ψ	Morgan metal class
M31	0.59	0.60±0.02	1.29±0.02	VIII
M32	0.50	0.47±0.02	1.02±0.03	—
NGC 6356	0.48	0.39±0.05	0.88±0.07	VI
M71	0.52	0.38±0.04	0.87±0.06	VI

globular clusters NGC 6356 and M71. The data in the table show that, for the nucleus of M31, the indices Δ, Φ, and Ψ are larger than those observed for the two least metal-deficient clusters observed during the present programme. The parameters Δ, Φ, and Ψ for the

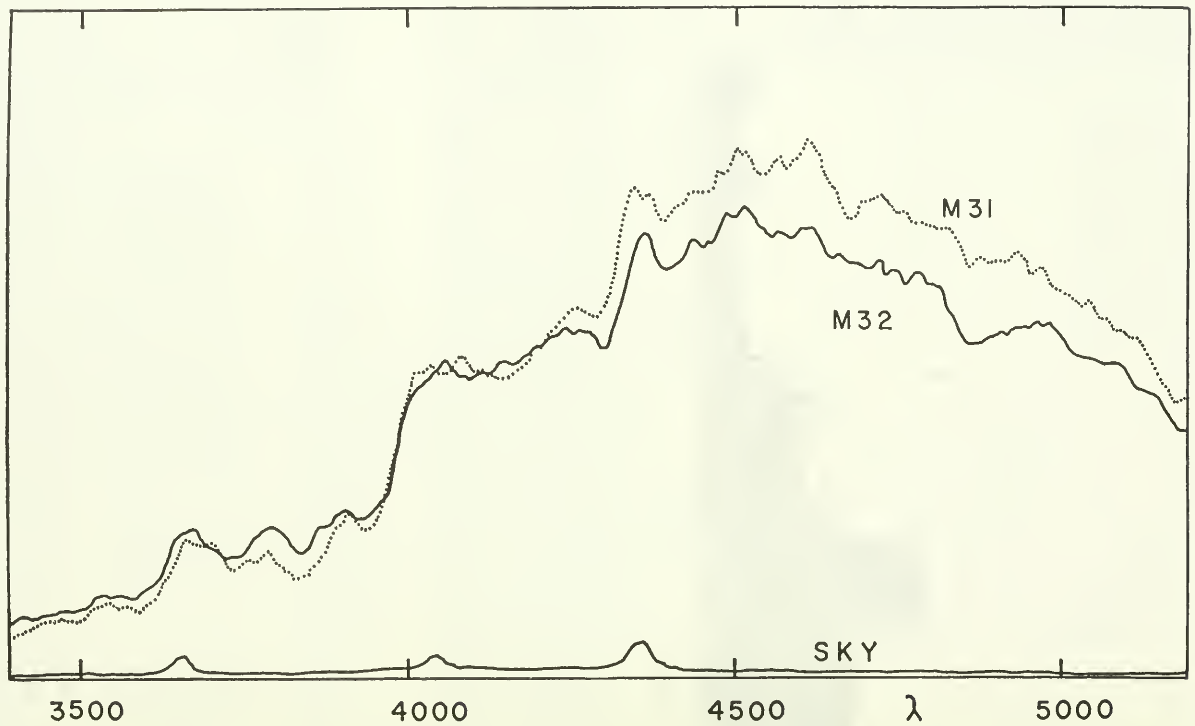

Fig. 14—Comparison of tracings of the nuclei of M31 and M32 with sky tracing superimposed. The figure shows that M32 is bluer than M31.

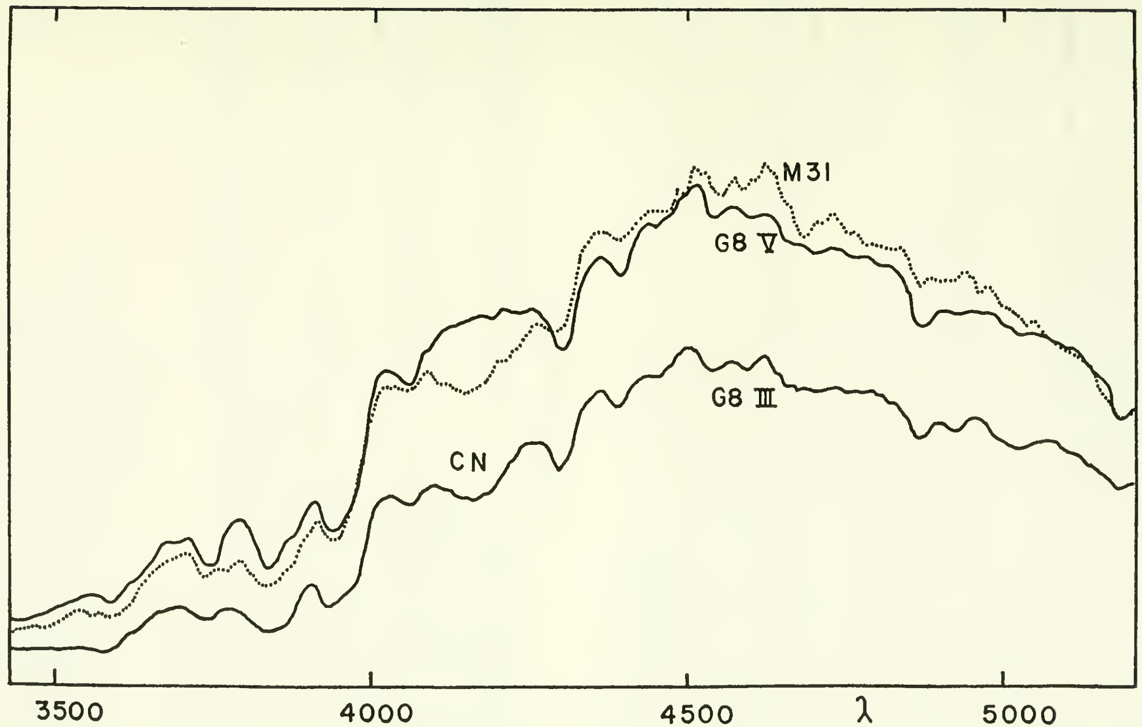

FIG. 15—Comparison of a tracing of M31 (with sky subtracted) with tracings of the stars η Psc (G8 III) and 61 UMa (G8 V). The strength of the cyanogen absorption in the tracing of M31 shows that giant stars contribute significantly to the total luminosity of the nucleus of M31 in blue light.

nucleus of M32 appear to be intermediate between those of M31 and those of the least metal-deficient globular clusters observed. Morgan (1959) lists four globular clusters which he considers to be metal-richer than M71 and NGC 6356. Unfortunately these clusters were either too far south or too faint to be observed during the present programme.

Figure 14 shows tracings of M31 and M32 obtained on the same night and at the same value of sec z. Comparison of these two tracings shows that M32 is considerably bluer than is M31.

Figure 15 shows a comparison of a tracing of M31 with tracings of a G8 III giant and a G8 V dwarf. For the scans of the two stars the width of the exit slot was increased to make the effective resolution similar to that on the tracing of M31. Comparison of the three tracings in the region between $\lambda\lambda$4100 and 4200 shows that "cyanogen giants" must provide a major contribution to the total radiation of the nucleus of M31 in the blue region of the spectrum. Morgan and Mayall (1957) have arrived at the same conclusion from an examination of low dispersion spectra of M31.

Acknowledgments

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References

Bless, R. C. 1958, Univ. of Michigan Ph.D. Dissertation.
Greig, W. E. 1962, Univ. of Toronto, M.A. Thesis.
Johnson, H. L. 1959, *Lowell Obs. Bull.*, vol. 4, p. 117.
Kinman, T. D. 1959, *R.A.S., M.N.*, vol. 119, p. 538.
Kron, G. E. and Mayall, N. U. 1960, *A. J.*, vol. 65, p. 581.
Mayall, N. U. 1946, *Ap. J.*, vol. 104, p. 290.

Michard, R. 1950, *B.A.N.*, vol. 11, p. 227 (no. 416).
Morgan, W. W. 1956, *P.A.S.P.*, vol. 68, p. 509; 1959, *A.J.*, vol. 64, p. 432.
Morgan, W. W. and Mayall, N. U. 1957, *P.A.S.P.*, vol. 69, p. 291.
Oke, J. B. 1960, *Ap. J.*, vol. 131, p. 358.
Whitford, A. E. 1958, *A.J.*, vol. 63, p. 201.
Wildey, R. L., Burbidge, E. M., Sandage, A. R. and Burbidge, G. R. 1962, *Ap.J.*, vol. 135, p. 94.
Young, A. T. 1962, *A.J.*, vol. 67, p. 286.

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SPECTROSCOPIC STUDIES OF 60 Be STARS OVER A PERIOD OF 24 YEARS

JUDITH A. COPELAND AND JOHN F. HEARD

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SPECTROSCOPIC STUDIES OF 60 Be STARS OVER A PERIOD OF 24 YEARS

By Judith A. Copeland and John F. Heard

Abstract

The spectra of 60 Be stars have been observed with a fair degree of regularity, about once a year, over the past 24 years for the principal purpose of surveying the spectral variations. A brief summary of the spectral characteristics and changes of each of these stars is here presented. For those stars showing double emission, studies of the fluctuations of the relative intensities of the violet and red components (V/R) have been made. For 15 of the stars it was possible to assign periods for these fluctuations; the mean period is about 6.8 years. About half of the stars show shell characteristics at times; the strength of the hydrogen absorption core intensities for about half of these shell stars show a degree of correlation with the V/R variations.

Introduction

Bright-line stars of class B are not uncommon. Merrill and Burwell (1933) in their "Catalogue of Be Stars" and in their two supplements (1943 and 1949) have listed 1088 such stars.

The emission lines in most Be stars are confined to the hydrogen lines, and invariably the emission is weaker as we proceed to the higher members of the Balmer series; indeed many such stars show emission only at Hα. Emission lines other than hydrogen are sometimes observed, e.g. Fe II, Mg II, Si II, Ni II, Cr II, He I. Main sequence B stars more commonly show emission lines than do the more luminous stars, and stars of spectral class B3 include a higher proportion of emission-line stars than do earlier or later classes.

It was shown by early investigations that the emission lines are almost invariably centred, or nearly so, within broad, dish-shaped absorption lines. This led Struve (1931) to the conclusion that the emission lines arise in a disk or ring cast off from rapidly rotating stars. The relatively few stars showing narrow single emission have also relatively narrow underlying absorption; they are explained as rotating stars which are presented "pole-on". The more common broad emissions (super-imposed on very broad absorption) are always double. The two components of the emission, violet (V) and red (R), frequently show variations in relative intensity (V/R) and also in position relative to the underlying absorption. The interpretation of these *V/R* variations and the concomitant velocity shifts has been difficult. McLaughlin (1961), who has observed a number of Be stars over a long period of time, put forward a model of an extensive envelope which both rotates and pulsates in such a way as to give rise to the *V/R* variation. Another model, first suggested by Struve (1931) and re-discussed by McLaughlin (1961), involves gaseous rings which are elliptical in shape. The choice between these two models hinges, in part, upon the observed Doppler shifts of the absorption core and the emission lines. Concerning these Doppler shifts there has been a difference of opinion between McLaughlin and Miss Underhill (1959).

The dark reversal (if it may be so termed) which separates the *V* and *R* components of double emission is sometimes so strong as to resemble the sharp cores in the so-called shell stars. Indeed when these shell-like reversals are marked, other lines, mostly of ionized metals, appear strong and sharp in absorption. The fact that shell characteristics appear in stars with rapid rotation lends support to the idea that the outer regions of the star's envelope, where the absorption cores are produced, are not rotating rapidly. In a number of Be stars the shell characteristic appears to come and go.

It appears that many more data will be required before satisfactory explanations can be found for all the curious features that are observed in the spectra of Be stars.

The Observations

One of us (J.F.H.) in 1938 selected from Merrill and Burwell's (1933) Mount Wilson Catalogue (M.W.C.) a list of 60 Be stars, most of which, at that time, were not being observed at Michigan where most of the detailed long-term observations of Be stars had been made. The writer's intention was to observe these stars once or twice per season over a long period of time in order to add to the store of knowledge of the spectral variations of Be stars. The intention was not fully realized for one reason and another (in particular there was a lacuna during the war years), but nevertheless a considerable collection of spectrograms was built up. For the benefit of other investigators who may be interested in these stars we give in Table I the number of spectrograms in our collection year by year. These spectrograms were taken with the Hilger one-prism spectrograph—

TABLE I

Number of Be-star Spectrograms Year by Year (1900+) in the D.D.O. Collection

M.W.C.	38	39	40	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
7	3	19		1	1	2																
8	3	1	1			3						1	1	1	1	1	1	1		1	1	
10	5	1	1			1						1	1	1	1	1	2	1	1	3	1	
13	4	1	1			2					4	2	1		1	1	2	3		2	2	
23	3	2	2			3	1	3		1	6	4	1	1	1	1	1	1	2	1	1	
29		3	1			1	1				2	1	1		2	1	1	1	2	1		1
49	2	1	1			2		1		1	9	1	1		2	1	1	1	1	1	1	
61	4					2	1			1	2	1	2	1	1		1				1	
63	3		1			1		1		1		1	1		1	2	1		1	1	1	
68	4						1	1		1	1	1	1	1	1	1	1	1	1	2	1	1
76		3	2			2		1		1	1	1	1	1		2	1	1	1	1		1
79	1	1	1			4	1		1			1	1		1	1	1	1	1	1	1	
82	1	1	2			2		1		1	1	1	1							2	1	
83		2				1			2	1	1		1			2	1		1	1		
86							2					1				1					2	
88	1	1										1			1	2	1			2	1	
93								1		2	1	2			1	1	1		1	1	1	
107	1											1		1		1			1	3	1	
114		1	1						3						1	2	1			1		
115	2								1	1					1					2	1	1
139		2	1			1			1	3	2	9		1		1	1		1			1
140		1												1		2	1		1	1	1	1
146		1												1		1	1			1	1	
156		1												2	2		1			2	1	
159		2							3							2						
164		1							3	2					1	1					1	
174			1						1	1			1			1						1
188		1	1						2	3				1	1					2	1	1
189			1						2	3	1	4		1						1		1
190		1													1	1				1		2
278	2	1				2	1			1	1	1	1	1	1	1	1	1	1	1		
292	1	1				2	1	2	1	1	1	1	1	1	1	1	1	1	1	2	2	
307		1	1			3	2			1	1	1	1	1	2	1		1	1	1	1	
308		2				1	2	1		1	1	1	1	1	1	1	1	1	1	2	1	
310		2				3	1	1		1	2	2	1	2	1	2	1	1	1	2	2	
312		2	2			2	1	1		1	24	1	1	3	1	1	1	1	1	3	1	
317	1	1				6	5	2		3	2	1	2	1	2	2	1	1	2	3	1	
320			3			1	2	2		1	1	1	1	2	1	1		1	1	2	1	
331	1	1				3					1	1	1	1	1	1	1	1	1	2	1	
332		1				2						1	1	1	1	1	2	1	1	3		

TABLE I—*Continued*

M.W.C.	38	39	40	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
336						2	1					1	1	1	2	1	1	1	1	2	1	
343		1				2						1	2	1	1	1	1	1		2	1	
346		2				2	3			1	3	1	2	1	1	1	1	1	1	3	1	
347	1					3	1			1	1	1	1	1	2	1	1	2		2	1	
350		1				1	1			1	1	1	1	1	1	1		1		2	1	
352	1					2						1	1	1	1	1		1		1	1	
353						1	1			1	1	1	1	1	1	1		1		1		
360	1	1				2						1	1	1	1	1		1		2		
361												2		1	1		1	1	1	2	1	
366	1					2						1	1	1	1	1	1	1	1	2	1	
371	2					2						1	1	1	1	1	1	1	1	2	1	
376	2		1			4	4			3	4	1	2	1	1	1	1	1	1	2	1	
381	3	1				3	3			4	3	1	1	1	1	1		1	1	1	2	
383	1	2	2			2						1	1	1	1	2	1	1	1	3	1	
394	2	1				5	3	1		1	2	1	1	1	1	1	1	1	2	1	1	
395	3					2	2	2		2	2	1	2	2	1	1	2	2	1	3	2	
397						11	43	8	33	2	2		1	1	2	1	1	1		3	1	
402	2	2	3			1	1	2	1	1	1	1	1	2	1	1	1	1	1	1		
407	5					3	1	1		1	1	2	1	1	2	2	1	1		3	2	
409	2	1	1			1	2	2		2	2	1	1	1	1	1	1	1	1	2	1	

most of them at dispersion 33 A./mm., some, especially of the stars fainter than magnitude 8, at dispersion 66 A./mm. Hα does not show on the spectrograms, and little is seen to the violet of λ 3900.

As the spectrograms were being accumulated a card catalogue was maintained listing the main spectral variations. In 1961 the other writer (J.A.C.) undertook a detailed re-examination of all the spectrograms and a tabulation and correlation of the results.

In Table II we list the stars according to both M.W.C. and H.D. numbers, giving R.A. and Dec. for 1900, the visual magnitude, and

TABLE II

SUMMARY OF SPECTRAL FEATURES AND VARIATIONS

M.W.C. 7, H.D. 2905; $0^h27^m.3$, $+62°23'$; $4^m.24$, cB0eα; κ Cas

No emission has been observed, though Hβ absorption is weak; no spectral variations were noted.

M.W.C. 8, H.D. 4180; $0^h39^m.2$, $+47°44'$; $4^m.7$, B4neβ; o Cas

In 1938, 1939, 1946 double emission at Hβ appeared faintly with $V = R$, and there was a deep core at Hγ. These features were not visible from 1952 on.

TABLE II—*Continued*

M.W.C. 10, H.D. 6343; $0^{h}59^{m}.4$, $+65°26'$; $7^{m}.10$, B5eβ

Hβ has single emission varying in intensity, particularly strong in 1946, 1958, 1959, Sept. 1960. Hγ shows weak emission when Hβ emission is strongest, but in Nov. 1960 Hγ showed a distinct absorption core and Hβ no emission.

M.W.C. 13, H.D. 9105; $1^{h}24^{m}.6$, $+62°51'$; $7^{m}.46$, cB5(e)

Absorption lines are very sharp; no emission was seen on any of the plates.

M.W.C. 23, H.D. 12302; $1^{h}55^{m}.6$, $+59°12'$; $8^{m}.2$, B3e

There are marked and rapid variations in the intensity and the V/R ratio of the double emission lines. Emission lines other than hydrogen appear. Shell characteristics come and go.

M.W.C. 29, H.D. 13661; $2^{h}08^{m}.1$, $+54°04'$; $8^{m}.6$, B(3)ne

The width and V/R ratios of Hβ and Hγ vary markedly. He I 4471 absorption is usually sharp but was broad in 1946 and exceptionally so in 1959.

M.W.C. 49, H.D. 15472; $2^{h}24^{m}.4$, $+70°30'$; $8^{m}.0$, B4ne

There are marked intensity and V/R changes in the double emission at Hβ and Hγ, and hydrogen absorption cores and other shell characteristics come and go. The relative intensity and sharpness of He I 4471 and Mg II 4481 vary.

M.W.C. 61, H.D. 19243; $3^{h}00^{m}.7$, $+62°00'$; $6^{m}.5$, B2e

There are marked intensity and V/R changes in the double emission at Hβ and Hγ. Though the hydrogen emission is broad, the He I absorption is narrow. Weak absorption cores of Hγ and Hδ appeared in 1953.

M.W.C. 63, H.D. 20017; $3^{h}07^{m}.9$, $+48°19'$; $7^{m}.9$, Bne

Hydrogen and He I have very broad absorption, and He I is very weak. The emission at Hβ and Hγ is weak and varies in width. V/R changes are noted, but frequently the double emission is difficult to resolve. An absorption core was seen at Hγ in 1938, 1946, 1953, 1955, 1956, 1957.

M.W.C. 68, H.D. 21650; $3^{h}24^{m}.6$, $+41°25'$; $7^{m}.2$, B5ne

There are marked variations of intensity and V/R ratios of double emission at Hβ and Hγ. Absorption cores at Hβ and Hγ come and go.

M.W.C. 76, H.D. 23982; $3^{h}44^{m}.3$, $+63°11'$; $8^{m}.1$, B3e

All absorption lines are broad. Weak, narrow, double emission is sometimes seen at Hβ and Hγ with $V = R$. In 1960 and 1962 an absorption core was seen at Hγ.

M.W.C. 79, H.D. 24560; $3^{h}49^{m}.3$, $+44°38'$; $7^{m}.8$, B(3)ne

Absorption lines are broad. Emission is usually absent, though suggested by the weakness of Hβ absorption, but in 1945 and in 1960 and 1961 there was fairly distinct narrow double emission at Hβ with $V \doteqdot R$.

M.W.C. 82, H.D. 26420; $4^{h}05^{m}.7$, $+41°52'$; $7^{m}.6$, B3neα

No emission was seen until 1960 when at Hβ double emission appeared with $V = R$; by 1961 both Hβ and Hγ showed $R > V$ and sharp absorption cores.

M.W.C. 83, H.D. 26906; $4^{h}10^{m}.1$, $+45°58'$; $8^{m}.6$, B(3)ne

From 1939 to 1951 Hβ showed strong double emission with $V = R$ and an absorption core at Hγ. On the plate of 1953 the Hβ emission was absent, but seems gradually to have re-appeared between 1956 and 1960 when it occurs as narrow emission to the red of the centre of both Hβ and Hγ, i.e. $R \gg V$.

TABLE II—*Continued*

M.W.C. 86, H.D. 28497; $4^h24^m.5$, $-13°17'$; $5^m.5$, B3ne

There is double emission at Hβ and Hγ with variations in the intensity, V/R ratio, and in the strength of the absorption cores.

M.W.C. 88, H.D. 29866; $4^h37^m.3$, $+40°36'$; $6^m.1$, B4ne

Emission at Hβ and Hγ is weak and sometimes resolved into double, sometimes not. There are V/R variations, and Hγ at times has an absorption core.

M.W.C. 93, H.D. 31293; $4^h49^m.4$, $+30°24'$; $7^m.5$ var., A0ep; AB Aur

Most plates show fairly wide emission to the red of centre at Hβ, Hγ and Hδ with a strong absorption core to the violet. The cores faded in 1950, returned in 1956, disappeared in 1957 and returned in 1959. The emission strengthened and became more nearly central when the cores disappeared. On the 1961 plate Hβ emission was double with $R > V$, Hγ double with $R = V$.

M.W.C. 107, H.D. 34921; $5^h15^m.8$, $+37°55'$; $7^m.4$, B0ne

Emission at Hβ and Hγ is double and there are well marked variations of V/R.

M.W.C. 114, H.D. 37115; $5^h31^m.0$, $-5°41'$; $8^m.2$, B5ne

All plates show moderately wide double emission at Hβ with $V = R$. Since 1940 there has been a sharp absorption core at Hγ, and since 1956 there has been double emission at Hγ with $V = R$.

M.W.C. 115, H.D. 37202; $5^h31^m.7$, $+21°05'$; $3^m.0$, B3e; ζ Tau

This well-known shell star exhibits many changes in the absorption and emission lines. The double emission lines at Hβ show marked variations of V/R, and the Hγ core shows variations in intensity along with the other shell lines. Double emission was seen at Hγ in 1955 and 1960 with $V = R$, but in 1961 only the violet component was seen.

M.W.C. 139, H.D. 44637; $6^h17^m.7$, $+15°09'$; $7^m.7$, B3e

Hydrogen absorption is very broad; He I absorption is moderately strong and sharp. Emission was seen only at Hβ, double with V/R varying, but usually with $V \doteq R$. Emission was weakest in 1950.

M.W.C. 140, H.D. 45314; $6^h21^m.6$, $+14°57'$; $7^m.1$, B2ne

All absorption lines are extremely broad and weak. Double emission with varying V/R was seen at Hβ and Hγ except on the last plate (1962) when no emission at all was seen.

M.W.C. 146, H.D. 45995; $6^h25^m.6$, $+11°19'$; $5^m.8$, B2ne

Absorption lines are broad and diffuse. Double emissions at Hβ and Hγ vary as to V/R.

M.W.C. 156, H.D. 50083; $6^h46^m.5$, $+5°13'$; $6^m.8$, B2e

Both Hβ and Hγ show double emission with V/R variations.

M.W.C. 159, H.D. 50209; $6^h47^m.1$, $-0°10'$; $8^m.3$, B(5)ne

Hydrogen absorption is very strong and broad; the relative strength of He I 4471 to Mg II 4481 varies considerably. Double emissions at Hβ, Hγ and (since 1949) at Hδ vary in width, strength and V/R.

M.W.C. 164, H.D. 52721; $6^h57^m.2$, $-11°09'$; $6^m.6$, B3e

Hydrogen absorption is wide but He I fairly narrow and variable in strength. In 1939 Hβ emission was narrow and fairly strong, and in 1950 Hβ emission was weaker

TABLE II—*Continued*

and Hγ had weak double emission with $R > V$; thereafter emission was apparently absent.

M.W.C. 174, H.D. 57386; $7^{h}15^{m}.9$, $-8°15'$; $8^{m}.1$, B5ne

Absorption lines are fairly wide and moderately weak. Hβ emission is fairly strong, wide and double with variable V/R. Hγ emission is weak and probably double.

M.W.C. 188, H.D. 65079; $7^{h}51^{m}.9$, $+3°14'$; $7^{m}.7$, B3ne

Hydrogen and He I absorptions are very broad. Hβ emission was moderately strong and double in 1939; it faded with time and changed slightly as to V/R; it was extremely weak in 1962. Hγ emission is weak, probably double but not always resolved.

M.W.C. 189, H.D. 65176; $7^{h}52^{m}.4$, $-1°20'$; $8^{m}.1$, B(5)ne

All absorption lines are extremely weak and broad. Weak Hβ emission was seen in 1949 and 1952, it was stronger in 1954 and double, with $V \doteqdot R$; it was weaker in 1960, stronger again in 1962. In 1954 Hγ emission was double, with $R = V$; it was weaker in 1960.

M.W.C. 190, H.D. 65875; $7^{h}55^{m}.8$, $-2°36'$; $6^{m}.4$, B2e

Hydrogen absorption lines are fairly wide, He I strong and fairly narrow. Hβ and Hγ emissions are narrow but probably double with V/R changes.

M.W.C. 278, H.D. 164284; $17^{h}55^{m}.3$, $+4°22'$; $4^{m}.8$, B5ne

Hydrogen and He I absorption lines are fairly wide. Weak double Hβ emission appeared at Hβ in 1946, was absent in 1951 and 1955, was very strong in 1959 and 1960. Hγ double emission also appeared in 1953, was absent in 1955 and 1956, was strong in 1959 and 1960. In all cases $V = R$.

M.W.C. 292, H.D. 168957; $18^{h}17^{m}.3$, $+25°01'$; $6^{m}.9$, B5e

All absorption lines are narrow. In 1938 emissions at Hβ, Hγ, Hδ, Hϵ were strong and narrow; emission was replaced in 1946 by absorption cores which faded and in 1951 were replaced by emission again. Emission was gone again in 1952, re-appearing in 1954, missing in 1958, replaced by absorption cores in 1959 which then faded in 1961. The alternation of hydrogen emission lines and absorption cores was accompanied by numerous changes in the many other absorption lines, e.g. He II 4686 was quite strong in 1954.

M.W.C. 307, H.D. 174886; $18^{h}47^{m}.7$, $-10°21'$; $8^{m}.1$, B3e

The hydrogen absorption is moderately wide, He I fairly sharp. Double Hβ and Hγ emissions vary in V/R, width and intensity—weakening in 1951, strengthening then weakening again from 1955 onward. Absorption lines vary considerably in strength and sharpness.

M.W.C. 308, H.D. 175863; $18^{h}52^{m}.3$, $+59°53'$; $6^{m}.9$, B4e

Hydrogen and He I absorption lines are fairly broad. A narrow single Hβ emission appeared in 1947, faded, and was gone by 1950. It returned in 1951 but was weak or absent later. The 1959 plate seems to show absorption cores at Hγ and Hδ.

M.W.C. 310, H.D. 177648; $19^{h}00^{m}.5$, $+23°11'$; $6^{m}.9$, B3e

Hydrogen and He I absorptions are fairly broad. Double Hβ emission comes and goes with variable V/R. When Hβ emission is strongest Hγ has an absorption core.

TABLE II—*Continued*

M.W.C. 312, H.D. 180398; $19^{h}11^{m}.3$, $+12°56'$; $7^{m}.7$, B(3)ne

Hydrogen and He I absorptions are broad. Double Hβ emission is always weak and varies as to intensity and V/R ratio. Absorption core and signs of emission borders are seen at Hγ when Hβ emission is most distinct.

M.W.C. 317, H.D. 183143; $19^{h}23^{m}.0$, $+18°05'$; $6^{m}.9$, cB9eα

This is a well-known, strongly reddened supergiant which shows the interstellar band at λ4430 very strongly. On our plates Hβ absorption is sometimes strong, sometimes practically filled in, as though variable emission is present. He I 4387 fluctuates in character between nebulous and sharp. On a plate of 1953 Sept. 8 a strong "absorption" feature appeared at λ4447.5; it was gone on 1953 Oct. 16, and was seen on no other plate before or since. The feature may be a flaw in the emulsion, but it gives every appearance of being a strong absorption line. If the line is real the writers can suggest only N II 4447.03 by way of identification.

M.W.C. 320, B.D. $+5°4285$; $19^{h}41^{m}.3$, $+5°44'$; $8^{m}.5$, B5ne

The absorption lines are extremely wide. Hβ and Hγ show double emission with strong cyclical variations in V/R.

M.W.C. 331, H.D. 192044; $20^{h}07^{m}.8$, $+26°11'$; $5^{m}.9$, B8ne

Hydrogen and He II absorption lines are wide, nebulous. The Hβ and Hγ emission lines are double, with variations in intensity and V/R. Cores show with varying sharpness at Hγ, Hδ, Hϵ.

M.W.C. 332, H.D. 192445; $20^{h}09^{m}.8$, $+36°02'$; $7^{m}.1$, B2ne

Hydrogen and He I absorptions are very wide and weak. Generally the double hydrogen emissions are strong, showing as far as Hϵ; there are cyclical variations in the strength, width and V/R ratios. Other emission lines (e.g. Fe II 4383, He I 4471) are seen at times.

M.W.C. 336, H.D. 193009; $20^{h}12^{m}.9$, $+32°04'$; $7^{m}.0$, B0ne

Absorption lines are very wide. Double emission at Hβ and Hγ show cyclical variations in V/R ratios. Fe II 4383 is often seen in emission.

M.W.C. 343, H.D. 194335; $20^{h}20^{m}.0$, $+37°10'$; $5^{m}.7$, B3ne

No emission was seen in 1939, but since 1946 double emission at Hβ has displayed V/R variations.

M.W.C. 346, H.D. 195407; $20^{h}26^{m}.0$, $+36°39'$; $7^{m}.7$, B3e

Hydrogen and He I absorption lines are broad and weak except at times when shell characteristics appear, producing many sharp absorption cores. Double emissions at Hβ and Hγ vary markedly as to V/R. Other double emissions appeared strongly at times (e.g. Fe II 4549 and 4583 in 1954). On several plates since 1952 a wide absorption appeared at about λ4650 (O II?).

M.W.C. 347, H.D. 195592; $20^{h}27^{m}.2$, $+43°59'$; $7^{m}.2$, cB1e

The hydrogen and He absorptions are sharp and strong, and many lines of Si III, N III, Si IV, O II appear. No emission was observed except insofar as Hβ absorption varies somewhat in strength.

M.W.C. 350, H.D. 196712; $20^{h}34^{m}.0$, $-2°46'$; $6^{m}.3$, B9e

The hydrogen absorptions are broad. At times we would classify as B8 or earlier, at other times as B9, as the ratio of He I 4471: Mg II 4481 varies. Hβ shows emission,

TABLE 11—*Continued*

broad and probably double, but never well resolved. Faint Hγ emission was present in 1960.

M.W.C. 352, H.D. 198183; 20^{h}43$^m_.$5, +36°07′; 4$^m_.$5, B6e; λ Cyg

The absorption lines are narrow and strong. No emission was observed and no changes.

M.W.C. 353, H.D. 198478; 20^{h}45$^m_.$5, +45°45′; 4$^m_.$9, cB2eα

This is the supergiant 55 Cyg. No emission was observed and no changes.

M.W.C. 360, H.D. 200310; 20^{h}57$^m_.$6, +45°46′; 5$^m_.$2, B3ne

The hydrogen absorptions are rather narrow, the He I absorptions broad. The 1946 plates showed double Hβ and Hγ emission with $V = R$. No emission was seen in 1952 and later. The 1962 plate showed a sharp core at Hγ.

M.W.C. 361, H.D. 200775; 21^{h}00$^m_.$4, +67°47′; 7$^m_.$2, B5e

Hydrogen absorptions are very broad, but He I and Mg II 4481 are fairly sharp. Strong double emissions at Hβ and Hγ show variations of V/R; "shell" absorption cores at Hγ and Hδ vary in intensity. An unidentified emission feature at λ4286 appeared on the 1955 plate.

M.W.C. 366, H.D. 203374; 21^{h}16$^m_.$7, +61°25′; 6$^m_.$6, B0ne

Hydrogen and He I absorptions are broad. Double emissions at Hβ and Hγ vary slightly as to V/R.

M.W.C. 371, H.D. 205060; 21^{h}27$^m_.$7, +42°16′; 7$^m_.$1, B5(n)e

In 1938 and 1946 hydrogen and He I absorptions were broad with "shell" cores, but no emission was seen. Since 1952 double emissions at Hβ and Hγ have appeared, varying in intensity and V/R ratio.

M.W.C. 376, H.D. 206773; 21^{h}39$^m_.$3, +57°17′; 7$^m_.$0, B0ne

The spectrum of this star is about the most interesting of our list, showing remarkable variations. In 1938 there were strong narrow central emissions at Hβ, Hγ, Hδ within broad weak absorptions. By 1940 Hβ and Hγ showed wide double emission ($V < R$), and Hδ was practically continuous. Thereafter the hydrogen emission doubles varied markedly in intensity, width and V/R. In 1951 the emission doubles were more like borders to strong absorption cores; He I lines shared this appearance with the hydrogen lines as far as they could be seen (to Hζ). In 1953 the doublets were narrow, and V was barely visible at Hγ and Hδ; in 1957 the V/R ratios were reversed; by 1958 the emission doublets were wider again and equal. Similar variations continued.

M.W.C. 381, H.D. 208682; 21^{h}52$^m_.$9, +64°52′; 5$^m_.$8, B3ne

Hydrogen and He I absorptions are broad and weak. Double hydrogen emissions vary in intensity and V/R. Other emissions, e.g. He I 4471, Fe II 4383 are present at times. Hydrogen absorption cores vary in strength.

M.W.C. 383, H.D. 209296; 21^{h}57$^m_.$2, +56°14′; 8$^m_.$1, B(5)e

On early plates hydrogen absorptions were broad and deep, He I weak, Mg II 4481 stronger than He I 4471; type was then more like B9 than B5. No emission was seen until 1952 when (and thereafter) double emissions with $V = R$ were present at Hβ and Hγ. By 1961 He I 4471 was much stronger than Mg II 4481. Hβ had an absorption core in 1946 which remained until 1956.

TABLE II—*Continued*

M.W.C. 394, H.D. 217050; 22^{h}52^m.7, +48°09′; 5^m.2, B3ne

The spectrum is that of a typical shell star with very sharp, strong hydrogen cores and many faint metal lines. Hβ and Hγ show double emissions with slight variations of V/R. Some other emissions show at times.

M.W.C. 395, H.D. 217543; 22^{h}56^m.3, +38°10′; 6^m.4, B3ne

The spectrum shows marked variations. On the 1938 plates strong hydrogen absorption cores appeared as far as Hζ on broad underlying absorptions; He I absorptions were broad and strong; the only emission was a suggestion of borders at Hβ. By 1946 the emission borders at Hβ were stronger, Mg II 4481 was nearly as strong as He I 4471, and numerous metal lines were appearing in absorption. In 1947 emission at Hβ was strong ($V = R$) and shell characteristics were more marked. By 1953 the emission at Hβ was weak or absent and the metal absorptions were very weak. In 1954 Hβ emission was stronger with $V > R$. Thereafter there were variations in the hydrogen emissions (intensity and V/R) and in the hydrogen core intensities, but the metal lines did not return in strength.

M.W.C. 397, H.D. 218393; 23^{h}02^m.6, +49°40′; 6^m.8, Ave

This well-known star, although classified as A-type, sometimes resembles a late B-type. It has a most peculiar spectrum, showing marked variations in both the absorption and emission lines. Our plates from 1938 to 1949 were studied in some detail by Halliday (1950) who discussed the coming and going of the α Cygni metal lines and the rhythmic variations in the radial velocities. The hydrogen absorptions are usually sharp, and there are usually double emissions at Hβ and Hγ at least. The V/R ratios do not show the common pattern of variations; instead, the variations are rapid and seemingly erratic, and more often than not the red component is much the stronger. It is when the emission doublets are nearly equal in intensity that the metal absorptions are the strongest and sharpest; they practically disappear when $R \gg V$.

M.W.C. 402, H.D. 223501; 23^{h}45^m.0, +61°39′; 8^m.2, B3e

Hydrogen absorptions are very broad, He I somewhat narrower. Hβ and Hγ were seen as double emissions on most plates with V/R variations. A weak Hγ absorption core was seen in 1938.

M.W.C. 407, H.D. 224559; 23^{h}53^m.8, +45°52′; 6^m.5, B3ne

Hydrogen and He I absorptions are very broad. Emission doublets at Hβ and Hγ are generally narrow, but vary in width and V/R. Hydrogen absorption cores vary in strength.

M.W.C. 409, H.D. 225095; 23^{h}58^m.3, +55°00′; 7^m.6, B1e

Hydrogen absorptions are wide, He I narrow. Hβ emission appears single, but Hγ and Hδ show emission doublets with V/R and intensity variations. He I 4471 varies in width and strength and an absorption core was seen at Hγ in 1960.

Mount Wilson spectral type. For each star there is a brief summary of the more detailed descriptions of the spectrum and spectral variations which are on our cards.

THE V/R VARIATIONS

Approximately 60 per cent of the Be stars in our list showed V/R variations. An attempt was made to study these for periodicity as follows: For both Hβ and Hγ, if possible, the V/R was estimated and classified according to the following scheme:

V/R Class	1	$V \ll R$
	2	$V < R$
	3	$V = R$
	4	$V > R$
	5	$V \gg R$

For each suitable line on each spectrogram the V/R classification was estimated three times and the mean taken. These classification numbers were then plotted as ordinates against time as abscissae, and the points were simply joined by straight lines.

Those plots which demonstrated clear evidence of periodicity for Hβ and/or Hγ V/R ratios are shown in figures 1 to 4 which include 15 of the 60 stars. (The ordinates of the plots are V/R classes as defined above.) It is apparent that the variations are not strictly periodic, and not every plot lends itself to an estimate of period; but an effort was made to assign a period to each star in the following manner: First we averaged the intervals between successive crossings of V/R class 3 ($V = R$); we noted that the Hβ periods tend to be longer than the Hγ periods for those stars for which both are available. Using a method of linear regressions, we then assigned to each star a period (the "adopted" period) which we believe to be a mean period for Hβ and Hγ suitably adjusted for the observed tendency of the Hβ period to be longer than the Hγ period. The Hβ, Hγ, mean, and "adopted" periods are given in Table III.

The "adopted" periods range from 875 to 3955 days (2.4 to 10.8 years). A histogram of these periods, shown in figure 4, demonstrates that the most frequent period is of the same order as the average period, namely 6.8 years. In assessing the significance of these results, however, one must remember that the stars selected are those which are in a stage of active V/R variability; by our method we may have automatically rejected stars which have slower fluctuations and which, over the past 24 years, have shown little variation of V/R.

A search for a correlation between period and spectral type yielded no positive result.

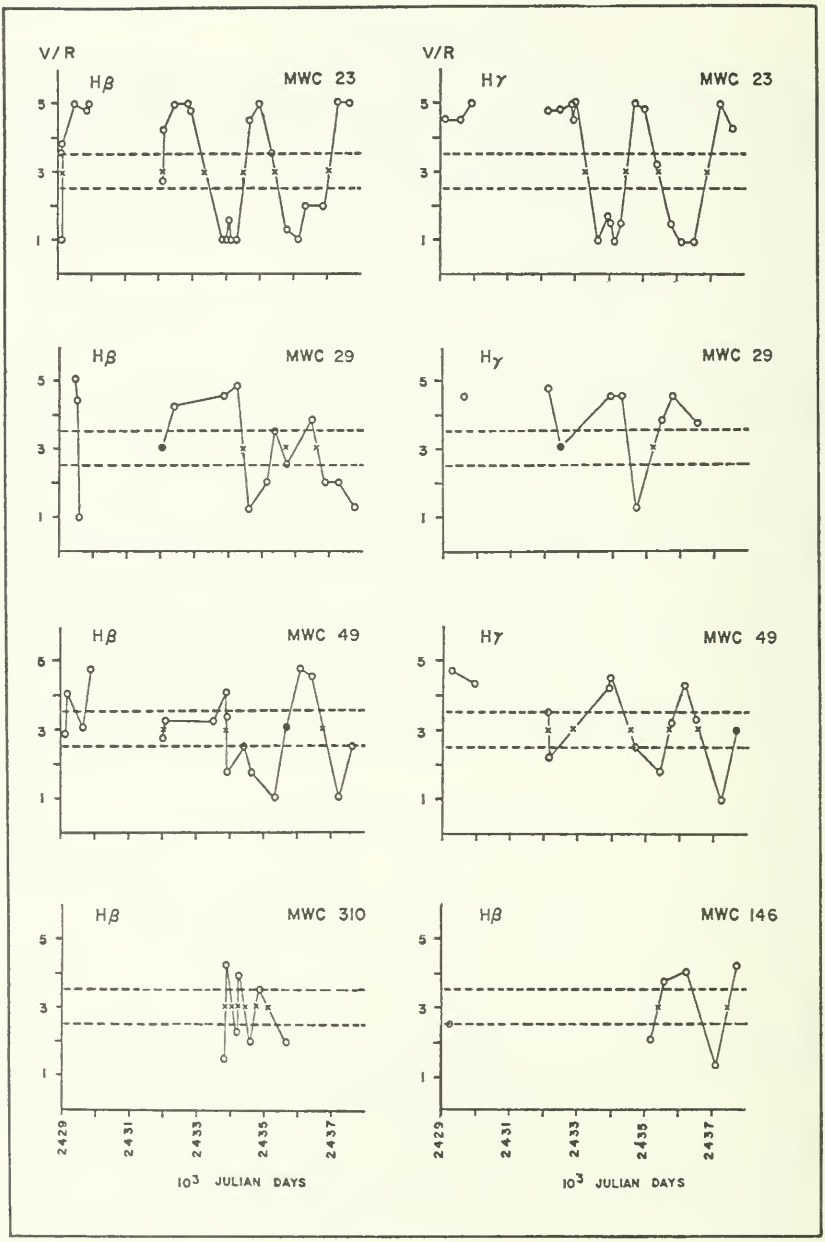
V/R
Hβ
MWC 23
Hγ
MWC 23
Hβ
MWC 29
Hγ
MWC 29
Hβ
MWC 49
Hγ
MWC 49
Hβ
MWC 310
Hβ
MWC 146
2429
2431
2433
2435
2437
10³ JULIAN DAYS

FIGURE 1

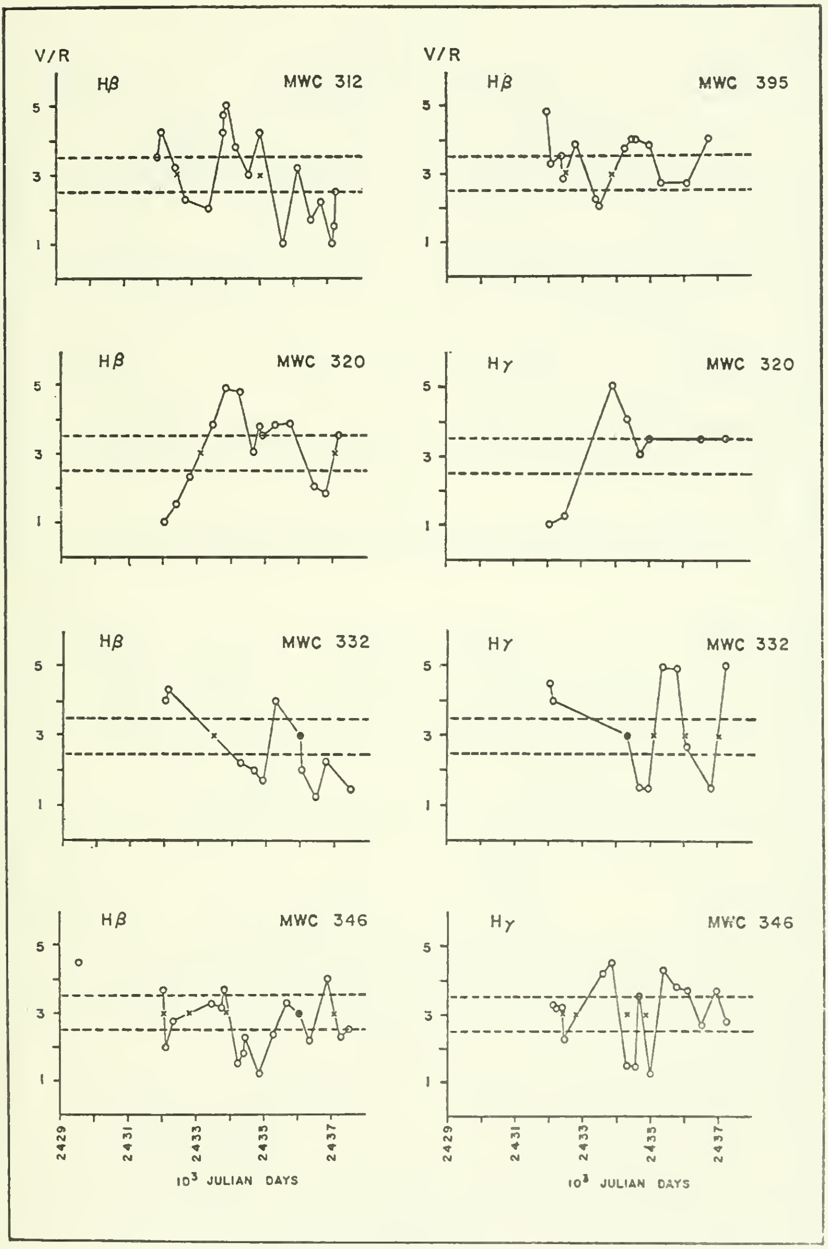
V/R
Hβ
MWC 312
V/R
Hβ
MWC 395
Hβ
MWC 320
Hγ
MWC 320
Hβ
MWC 332
Hγ
MWC 332
Hβ
MWC 346
Hγ
MWC 346
5
3
1
2429
2431
2433
2435
2437
10^3 JULIAN DAYS

FIGURE 2

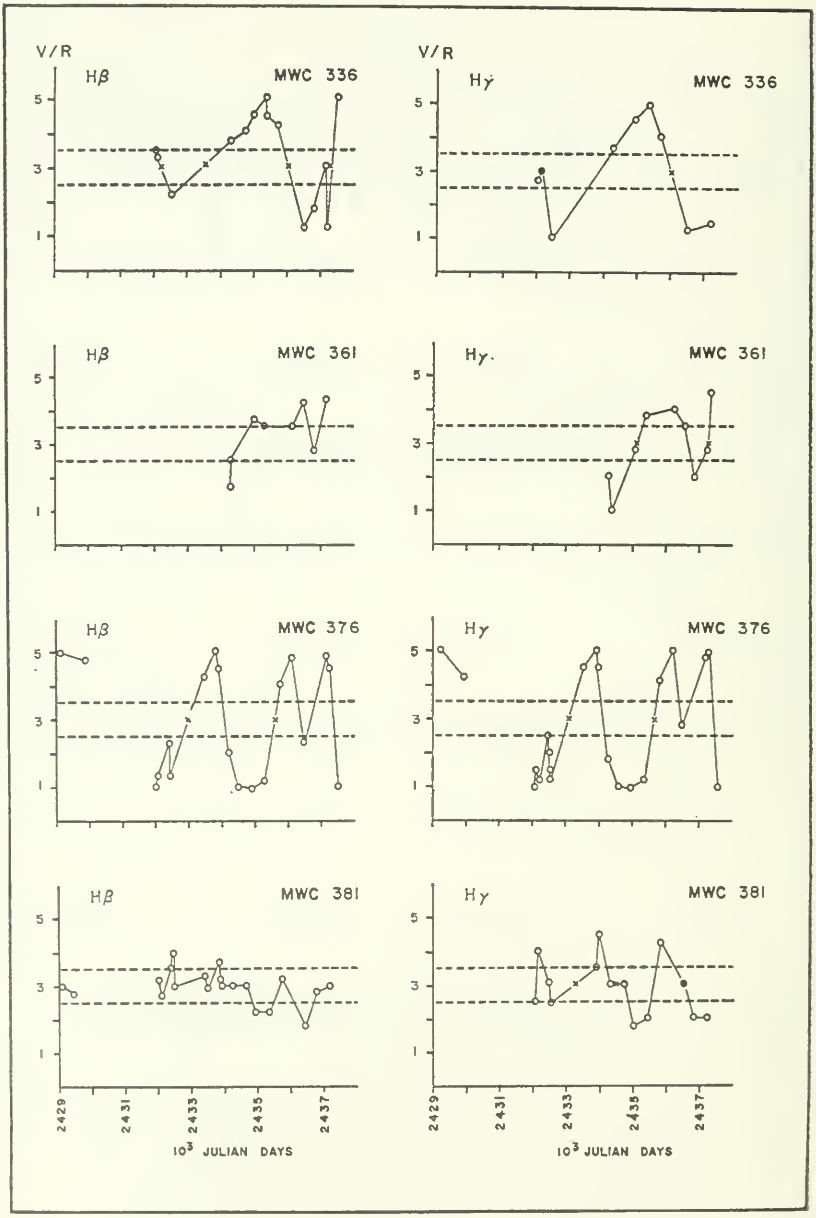
V/R
Hβ
MWC 336
V/R
Hγ
MWC 336
Hβ
MWC 361
Hγ
MWC 361
Hβ
MWC 376
Hγ
MWC 376
Hβ
MWC 381
Hγ
MWC 381
5
3
1
2429
2431
2433
2435
2437
10³ JULIAN DAYS
10³ JULIAN DAYS

FIGURE 3

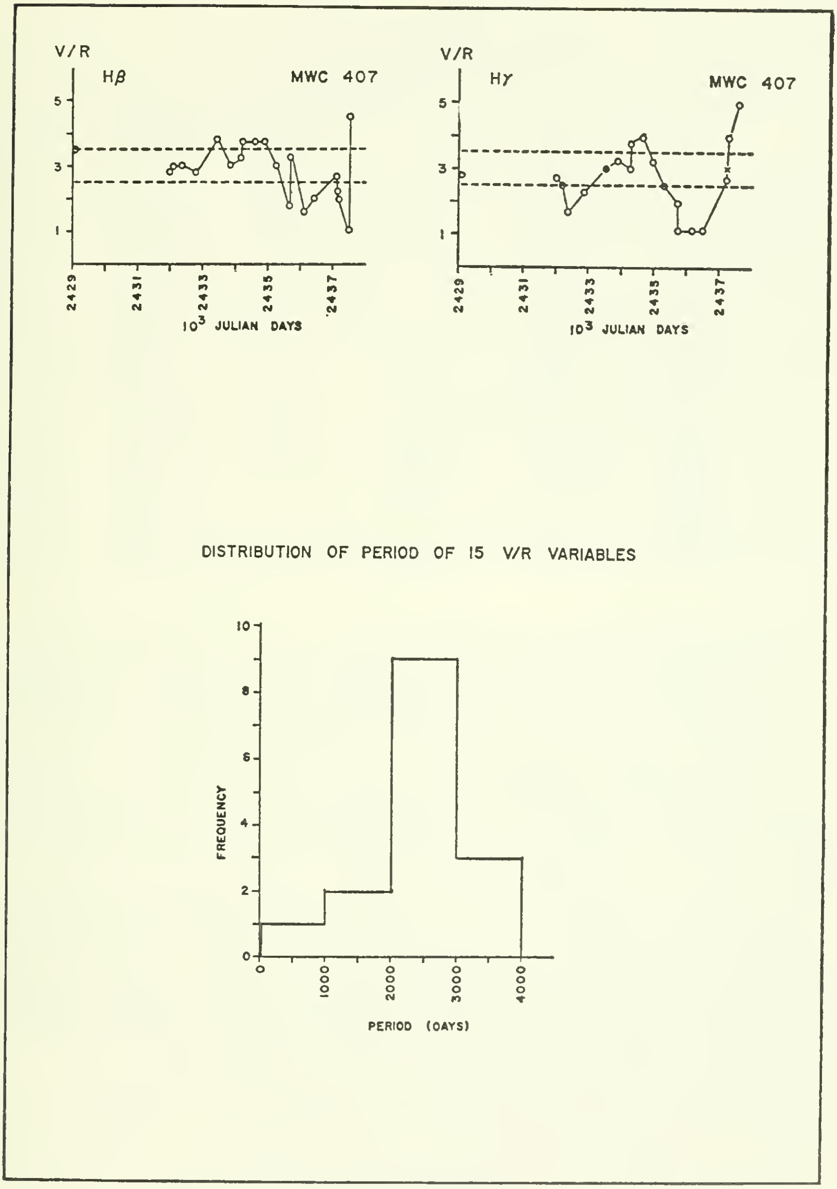
V/R
Hβ
MWC 407
10³ JULIAN DAYS
V/R
Hγ
MWC 407
10³ JULIAN DAYS
DISTRIBUTION OF PERIOD OF 15 V/R VARIABLES
FREQUENCY
PERIOD (DAYS)

FIGURE 4

TABLE III

V/R PERIODS OBTAINED FOR 15 STARS

Periods in days

MWC	Hβ	Hγ	Mean	Adopted
23	2461	2296	2379	2360
29	2850	2720	2785	2798
49	3097	2291	2694	2702
146	2160			1980
310	1052			875
312	2425			2250
320	3890			3720
332	2580	1790	2185	2145
336	3805	3830	3818	3955
346	2813	1950	2382	2360
361		2090		2340
376	2440	2540	2490	2472
381		2155		2390
395	1500			1325
407		3660		3610

There does appear to be a tendency for the Hγ V/R amplitudes to be greater than the Hβ amplitudes: of the 11 stars for which the data are sufficient, seven show Hγ amplitudes to be the greater, one shows Hβ amplitude the greater, and three show equal amplitudes. In a qualitative way this tendency might find an explanation on the rotating–pulsating model: the Hγ central absorption, being formed at a lower level in the envelope might be expected to be subjected to wider velocity oscillations and so give rise to more notable V/R variations in the emission doublets.

For four out of the 15 stars, the phase wherein $V \gg R$ is definitely longer than that for $R \gg V$, whereas for the other 11 stars there is no noticeable asymmetry of this sort. On the rotating–pulsating model $V \gg R$ corresponds to the contracting phase of the shell; it would thus appear that in some stars this phase lasts longer than the expanding phase.

STARS WITH SHELL CHARACTERISTICS

For practically all the stars which show definite V/R variations we have noted variations in the intensities of the hydrogen absorption cores (shell characteristics). Eye estimates of these core intensities were made and plotted alongside the V/R curves. No exact correlation was apparent, but, generally speaking, the strongest core intensity very frequently coincided with the $V \gg R$ phase or followed it by an interval of less than one quarter of the V/R period.

Taking account of all 60 of the stars investigated, 29 were noted as showing shell characteristics (in the hydrogen lines at least) at some time during the period of observation. These stars are M.W.C. 8, 10, 23, 49, 63, 68, 76, 82, 88, 93, 114, 115, 159, 292, 310, 312, 331, 346, 352, 360, 361, 371, 376, 381, 383, 394, 395, 397, 407. All but four of these stars are of Mount Wilson spectral types B3, B4 or B5; the exceptions are: M.W.C. 93 (A0), M.W.C. 331 (B8), M.W.C. 352 (B6), M.W.C. 397 (A). This clustering of shell spectra about B3–B5 types confirms an observation by Struve (1942). We further noted, by simple averaging of spectral types, that the shell Be stars in our sample are very close to B4, whereas the non-shell Be stars are close to B3. The difference, we believe, is significant, indicating therefore a tendency for the shell characteristic to be somewhat rarer in the earlier-type Be stars.

Conclusions

Our conclusions from a sample of 60 Be stars chosen without reference to known spectral characteristics and observed over a period of 24 years may be summarized as follows:

Fifty-four of the stars have shown emission at Hβ. Of the remaining six, five are supergiants.

Of the 54 stars showing emission at Hβ, 36, that is, 67 per cent, have been classed as V/R variables.

Periods have been determined for 15 of the V/R variables. The mean period is 6.8 years.

Twenty-nine of the stars showed, at some time or other, shell characteristics. These were nearly all of spectral types B3 to B5, and on the average were a little later than the Be stars which did not show shell characteristics. Fifteen of the shell stars are V/R periodic variables; among most of these stars maximum absorption core intensity tends to coincide with the phase $V \gg R$, or follow it by a small fraction of the period.

Acknowledgments

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We thank Mr. Michael Copeland for his help in preparing the diagrams.

References

Halliday, I. 1950, *Jour. R.A.S.C.*, vol. 44, p. 149.

McLaughlin, D. B. 1961, *Jour. R.A.S.C.*, vol. 55, p. 73.

Merrill, P. W. and Burwell, C. G. 1933, *Ap. J.*, vol. 78, p. 87; 1943, *Ap. J.*, vol. 98, p. 153; 1949, *Ap. J.*, vol. 110, p. 387.

Struve, O. 1931, *Ap. J.*, vol. 73, p. 94; 1942, *Ap. J.*, vol. 95, p. 134.

Underhill, A. 1959, *Jour. R.A.S.C.*, vol. 53, p. 176.

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A BIBLIOGRAPHY OF INDIVIDUAL GLOBULAR CLUSTERS

FIRST SUPPLEMENT

HELEN B. SAWYER HOGG

UNIVERSITY OF TORONTO PRESS, 1963

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Printed in Canada

A BIBLIOGRAPHY OF INDIVIDUAL GLOBULAR CLUSTERS

FIRST SUPPLEMENT

By Helen B. Sawyer Hogg

I. Purpose

The first bibliography of individual globular clusters was published by the writer in 1947 as volume 1, no. 20, of the Publications of the David Dunlap Observatory. Until that time, the extensive bibliographical material on globular clusters had been in an unwieldy state, so that a worker who wished to determine what had been done on any given cluster could do so only by a vast amount of searching of irrelevant material. That such a compilation was needed has been proved by the number of requests the Observatory has had for it.

Since that time, the card catalogue which formed the basis of that publication has been maintained continuously by the writer, who looks over all the astronomical literature of the world as it is received at the David Dunlap Observatory. From this catalogue this first supplement has been compiled, to include the literature from 1948 through 1962, as well as earlier references brought to the writer's attention since the publication of the first bibliography. Of course, the Astronomischer Jahresbericht and the Bulletin Signalétique of the Centre National de la Recherche Scientifique are a great help in providing information. In the future it is definitely planned to issue supplements at shorter intervals of time.

The literature on all clusters, both globular and galactic, is in a much better state of co-ordination than it was at the time of the original bibliography. This has been achieved through the efforts of G. Alter, J. Ruprecht and V. Vanýsek of Prague in their publication of the "Catalogue of Star Clusters and Associations," 1957. In this monumental work, all references are indexed on cards 148 by 208 millimetres under the individual clusters. Five annual supplements have already appeared, each as an Appendix to the Bulletin of the Astronomical Institutes of Czechoslovakia, and a sixth is in preparation. The writer is a co-author in these supplements. References to the original work in 1957 are indexed under individual clusters in this

David Dunlap bibliography, but the supplements are only listed by title in Section B because the references they contain are included in this present work.

Despite this other bibliography, the writer considers that there is still a need for the present publication. The formats of the Czech and Canadian bibliographies are quite different, and each has its own area of usefulness. The Czech bibliography, for lack of space on the cards, does not give the title of the paper or the initials of the author, or the name of more than one author. The abbreviation of references has to be truncated, and the arrangement is not fully chronological or alphabetical. The David Dunlap Observatory bibliography attempts to avoid all of these difficulties.

II. Use of the Bibliography

The form of this supplement is essentially the same as that of the original bibliography. The plan for listing is as follows. A paper which deals principally with one, or a few, clusters is listed by author and title under each cluster in Section A. If a paper whose title is listed under one cluster (with which it is chiefly concerned) refers briefly to other clusters, this is noted under each of them by a "See also" direction. On the other hand, a paper which is concerned with lists of many clusters, or one on a general subject which makes brief reference to a specific cluster, is listed under the cluster by date and author only. The title and complete reference will be found in Section B, which is arranged chronologically by year, and alphabetically by author within each year. When an author in this section has more than one paper in a year, a Roman numeral following the date distinguishes the paper. As a guide for the reader, many of these longer and more important references have been broken down into sub-sections, so that a perusal of Section B will show the sort of information the longer papers contain. We wish to interject a note of caution here, that some important papers on globular clusters are not included in this supplement because there is no mention of a specific cluster.

The actual abbreviations for references have been carried on as in the first bibliography. In general the name of the place appears first, and the type of publication second. The word observatory is frequently taken for granted. Because of the fact that the bibliography is built up piece by piece over a long period of time, it is hard to achieve a complete uniformity in it. When useful plates or photographs accompany an article, this is usually, but not always, noted. Symposia are usually indexed under the year of publication which is frequently later than the year of presentation. An attempt has been made to include, as well as periodicals, astronomical books which contribute pertinent information. In general, material mentioned by directors in their observatory reports is not indexed because its usefulness is ultimately supplanted by the full publication of the research. In special instances, however, an observatory report has been included.

It is inevitable that in a work of this magnitude errors and omissions will occur, though every effort is made to keep these to a minimum. It has not been possible to include references from a few semi-popular periodicals in some foreign languages which are little understood in the English-speaking world, and hard to obtain in North America. Most of these accounts are popular interpretations of scientific papers published in regular journals and their omission is probably not serious.

Because the study of variable stars in globular clusters constitutes an active branch of this field, we wish to note that references which give information on specific variables in globular clusters have been published by the writer in the two catalogues of variables in globular clusters, Publications of the David Dunlap Observatory, volume 1, no. 4, 1939, and volume 2, no. 2, 1955. Recently an article by Richard Stothers, *A. J.*, v. 68, p. 242, 1963 (which is beyond the chronological scope of this bibliography) gives an extensive reference list for slow variables in globular clusters.

III. Clusters included in this Bibliography

In this supplement are included all clusters belonging to our galaxy which are currently classified as globular. Also included are several of the more recently discovered globular clusters, such as those from the Palomar list of Abell, which are well beyond the recognized limits of our own galaxy, but bear no obvious relation to any other. Not included in this bibliography are clusters which are considered members of the Magellanic Clouds or of any other external galaxies.

With the above restrictions, 119 globular clusters are included. Figure 1 shows the distribution of these clusters in the new galactic co-ordinates, l^{II} and b^{II}.

Table I is a catalogue of 119 globular clusters with some of the current data about them. The table is arranged in order of NGC number, and therefore not always in order of current right ascension. If there is no NGC number, the arrangement is by right ascension. New clusters are named for the observatory at which they were announced.

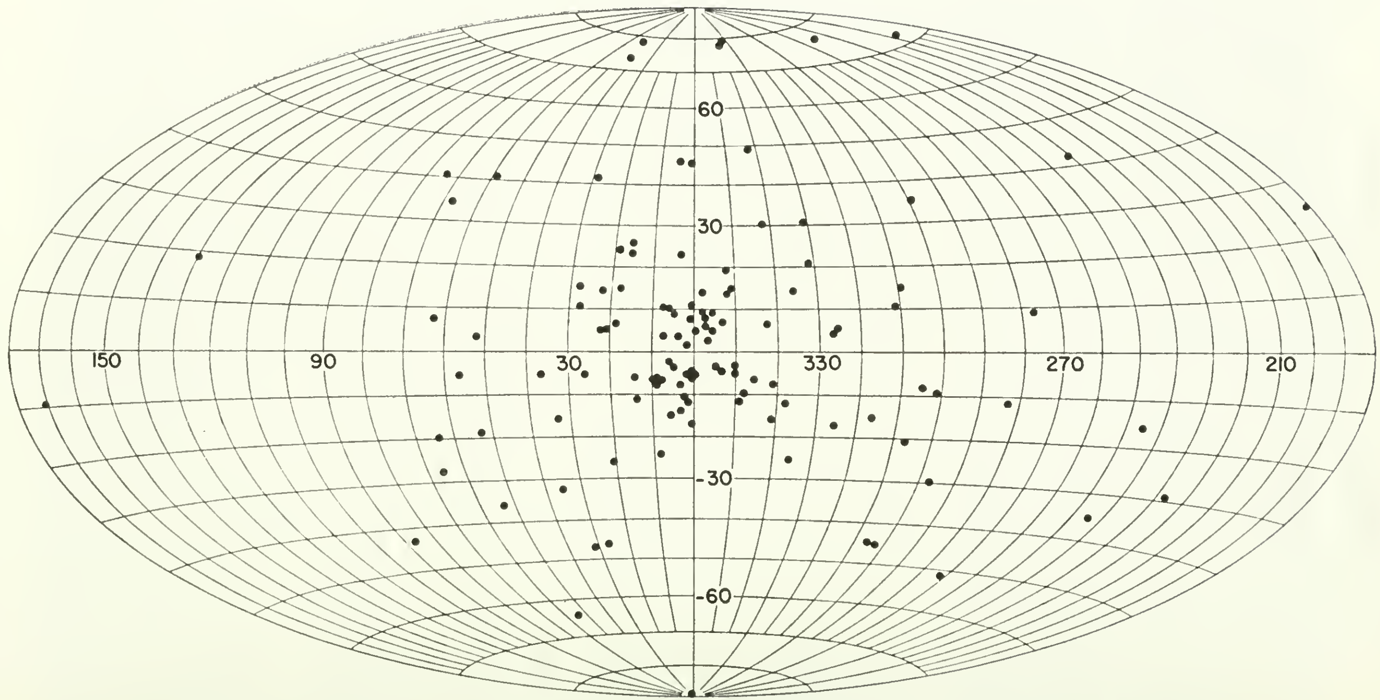

Fig. 1—Distribution of 119 globular clusters in galactic co-ordinates, on the new standard system.

TABLE I

CATALOGUE OF 119 GLOBULAR CLUSTERS

No.	R.A. 1960	Dec.	l^{II}	b^{II}	Conc.	Ang. diam.	Int. mag.	Sp. type	Colour P–V	Rad. vel. km./sec.	No. vars.	Mag. 25 br. st.	App. mod.	D kpc.
	h m	° ′	°	°		′								
104	00 22.3	−72 18	305.89	−44.90	III	44	4.68	G3		− 24	11	13.44	14.5	6
288	00 50.7	−26 49	149.66	−89.40	X	12.4	8.96			− 47	1	14.80	15.7	12
362	01 00.9	−71 04	301.64	−46.25	III	17.7	8.0	F8		+221	14	14.12	15.7	12
1261	03 11.2	−55 23	270.56	−52.12	II	4.0	9.5	F8		+ 46				29
Pal 1	03 27.2	+79 30	130.02	+19.06	XII	1.3					0	19		
Pal 2	04 43.7	+31 24	170.49	−08.98	IX	1.7								
1841*	04 51.0	−84 04	297.02	−30.15		2.4	12.2							
1851	05 12.7	−40 04	244.49	−35.05	II	11.5	7.72	dF5		+309	2			17
1904	05 22.6	−24 33	227.23	−29.33	V	7.8	8.39	dF3		+196	5	15.29	16.3	15
2298	06 47.6	−35 58	245.63	−16.01	VI	4.2	10.48	F8		+ 64	6			30
2419	07 35.5	+38 59	180.37	+25.25	II	6.2	11.51	F5	0.64	+ 14	36	17.84	18.8	62
2808	09 11.1	−64 41	282.18	−11.26	I	18.8	7.8	F8		+101	4	14.9	16.2	8
Pal 3	10 03.5	+00 15	240.16	+41.86	XII	2.2					1			
3201	10 15.9	−46 12	277.21	+08.64	X	29.3	8.8			+493	77		15.08	4
Pal 4	11 27.1	+29 12	202.31	+71.80	XII	2.5	14.4				2	19.90	20.5	125
4147	12 08.1	+18 46	252.89	+77.19	VI:	4.1	11.01	A5	0.48	+191	16	16.58	17.06	26
4372	12 23.6	−72 27	301.01	−09.90	XII	19.8	9.1			+ 66	0			6
4590	12 37.3	−26 32	299.62	+36.04	X	9.8	9.12	A6	0.59	−116	38	14.80	16.1	12
4833	12 56.7	−70 39	303.59	−08.01	VIII	12.7	8.5			+204	10		15.65	5
5024	13 11.0	+18 23	333.00	+79.76	V	14.4	8.68	F4	0.50	−112	43	15.07	16.7	20
5053	13 14.4	+17 54	335.55	+78.95	XI	8.9	10.9		0.55		10	15.6	16.4	17
5139	13 24.4	−47 06	309.10	+14.97	VIII	65.4	4.25	F7		+230	165		14.65	5
5272	13 40.4	+28 35	42.24	+78.70	VI	18.6	7.21	F7	0.56	−153	189	14.23	15.7	13
5286	13 43.6	−51 10	311.57	+10.58	V	13.6	9.5	F8		+ 45	0			12
5466	14 03.6	+28 43	42.13	+73.59	XII	9.2	10.39		0.64		22	15.72	16.4	16

*A. D. Thackeray wonders if this cluster is really a member of the Magellanic Clouds.

TABLE 1—*continued*

CATALOGUE OF 119 GLOBULAR CLUSTERS

No.	R.A. 1960	Dec.	l^{II}	b^{II}	Conc.	Ang. diam.	Int. mag.	Sp. type	Colour P–V	Rad. vel. km./sec.	No. vars.	Mag. 25 br. st.	App. mod.	D kpc.
	h m	° ′	°	°		′								
5634	14 27.5	−05 48	342.22	+49.26	IV	3.7	10.8	F4	0.56	− 63	7	16.32	17.1	23
5694	14 37.3	−26 22	331.06	+30.37	VII	2.2	10.87	A9	0.61	−187	0	16.79	17.7	32
14499	14 54.2	−82 04	307.36	−20.50	XI	6.2	11.6							
5824	15 01.5	−32 55	332.55	+22.06	I	3.7	10.08	dF5	0.63	− 58	27			46
Pal 5	15 14.0	+00 03	00.86	+45.87	XII	10.3					5	16.90	16.90	24
5897	15 15.1	−20 52	342.94	+30.29	XI	8.7	9.61		0.62		4	15.26	16.2	14
5904	15 16.5	+02 14	03.86	+46.80	V	19.9	7.04	F5	0.63	+ 49	97	13.97	15.2	9
5927	15 25.1	−50 31	326.63	+04.86	VIII	12.0	9.7	G2		− 96				3
5946	15 32.5	−50 32	327.58	+04.19	IX	2.6	11.0							
5986	15 43.5	−37 39	337.04	+13.28	VII	6.0	8.72	G0	0.75	+ 2	5		15.78	14
Pal 14	16 09.4	+15 03	28.77	+42.15		8.4					0			
6093	16 14.7	−22 53	352.67	+19.45	II	5.1	8.39	dF4	0.76	+ 18	8	14.88	16.05	11
6101	16 21.1	−72 07	317.73	−15.83	X	14.6	10.2							
6121	16 21.2	−26 25	350.99	+15.97	IX	22.8	7.41		0.92	+ 65	43	13.11	13.97	3
6139	16 25.0	−38 45	342.37	+06.94	II	2.6	10.4	F8		+ 20				13
6144	16 24.8	−25 57	351.92	+15.68	XI	6.2	10.85		0.82		1	15.76	16.0	10
6171	16 30.3	−12 58	03.37	+23.02	X	7.8	10.10	G2	0.97	−147	24	15.5	16.2	8
6205	16 40.3	+36 32	59.00	+40.91	V	23.2	6.78	F5	0.57	−241	10	13.75	14.8	8
6218	16 45.1	−01 53	15.70	+26.32	IX	12.2	7.95	F7	0.77	− 16	1	13.97	15.2	7
6229	16 45.9	+47 36	73.64	+40.30	IV	3.8	10.26	F7	0.64	−150	22	16.18	17.7	28
6235	16 51.0	−22 07	358.91	+13.52	X	1.9	10.8				2	16.24	17.13	16
6254	16 55.0	−04 03	15.13	+23.07	VII	12.2	7.64	G0	0.79	+ 71	3	14.06	15.2	7
Pal 15	16 58.1	−00 29	18.89	+24.27										
6266	16 58.7	−30 04	353.58	+07.30	IV	6.3	8.16	F8	0.95	− 75	83	15.87	16.74	8
6273	17 00.1	−26 12	356.88	+09.40	VIII	5.3	8.29	F5	0.90	+102	4	14.80	15.95	7

TABLE I—*continued*

CATALOGUE OF 119 GLOBULAR CLUSTERS

No.	R.A. 1960	Dec.	l^{II}	b^{II}	Conc.	Ang. diam.	Int. mag.	Sp. type	Colour P–V	Rad. vel. km./sec.	No. vars.	Mag. 25 br. st.	App. mod.	D kpc.
	h m	° ′	°	°		′								
6284	17 02.1	−24 42	358.37	+09.93	IX:	2.7	10.61	F8	0.91	+ 22	6	16.06	17.26	17
6287	17 02.7	−22 39	00.13	+11.04	VII	2.7	11.24		1.13		3	16.08	17.28	10
6293	17 07.7	−26 31	357.64	+07.84	IV	3.5	9.38	F5	0.86	− 73	5	15.39	16.69	12
6304	17 12.0	−29 25	355.84	+05.37	VI	3.8	9.82	G5	1.22	− 98	11		16.38	6
6316	17 14.0	−28 06	357.17	+05.78	III	2.4	10.10		1.17					
6325	17 15.6	−23 43	00.98	+07.99	IV:	1.6	12.66		1.52					
6333	17 16.8	−18 29	05.53	+10.72	VIII	5.5	8.92	F2	0.87	+224	13	15.50	16.39	8
6341	17 15.9	+43 11	68.35	+34.86	IV	12.2	7.30	F2	0.53	−118	16	13.86	15.2	10
6342	17 18.8	−19 33	04.90	+09.73	IV	1.3	11.35		1.20					
6352	17 22.4	−48 27	341.37	−07.19	XI:	8.9	9.1							
6355	17 21.5	−26 20	359.58	+05.42		1:	9.6		1.41					
6356	17 21.3	−17 47	06.73	+10.21	II	3.5	9.68	G5	1.06	+ 31	5	16.38	17.2	11
HP 1	17 25.5	−29 58	357.06	+02.65	IX	1.3								
6362	17 27.6	−67 01	325.54	−17.56	X	8.5	8.3			− 18	31			7
6366	17 25.6	−05 03	18.42	+16.03	XI	5.8	12.1				2	15.78	16.25	2
6380	17 32.6	−39 02	350.28	−03.56										
6388	17 33.3	−44 43	345.54	−06.74	III	6.8	8.7	G3		+ 81				13
Ton 2	17 33.4	−39 02	350.79	−03.42										
6397	17 37.6	−53 39	338.18	−11.98	IX	19:	7.3	F5		+ 11	3	12.61	13.0	2
6401	17 36.2	−23 53	03.45	+03.97		1			1.17:					
6402	17 35.5	−03 15	21.30	+14.78	VIII	6.7	9.44	G0	1.12	−129	72	15.44	16.72	7
Pal 6	17 41.2	−26 12	02.09	+01.78	XI	1.8						20		
6426	17 42.9	+03 12	28.07	+16.28	IX	2.2	12.33		0.85		12			21
6440	17 46.5	−20 21	07.72	+03.80	V	1.7	12.05	G5	1.81	−133				4
6441	17 47.5	−37 02	353.53	−05.00	III	3.0	8.93	G2		− 70				9

TABLE I—*continued*

CATALOGUE OF 119 GLOBULAR CLUSTERS

No.	R.A. 1960	Dec.	l^{II}	b^{II}	Conc.	Ang. diam.	Int. mag.	Sp. type	Colour P–V	Rad. vel. km./sec.	No. vars.	Mag. 25 br. st.	App. mod.	D kpc.
	h m	° ′	°	°		′								
6453	17 48.7	−34 37	355.74	−03.97	IV	3.6	11.4		1.04:					
6496	17 56.2	−44 15	348.08	−10.01	XII	12.7	10.3							
6517	17 59.6	−08 57	19.23	+06.77	IV	1.0	12.90		1.67					
6522	18 01.0	−30 02	01.03	−03.93	VI	1.5	10.40	F8	1.02		9		17.77	12
6528	18 02.2	−30 04	01.13	−04.17	V	1.2	11.04		1.27		0			
6535	18 01.8	−00 18	27.18	+10.43	XI:	1.3	11.9				1	15.97	16.88	14
6539	18 02.6	−07 35	20.80	+06.78	X	3.5	12.39		1.67		1			
6541	18 05.0	−43 44	349.28	−11.19	III	23.2	7.9	F6		−148	1	13.35	14.67	4
6544	18 04.9	−25 01	05.83	−02.22		1:		G1	1.27	− 12				5
6553	18 06.9	−25 56	05.25	−03.06	XI	3.2	10.20		1.39		6			
6558	18 07.7	−31 47	00.19	−06.02							9			
I 1276	18 08.5	−07 14	21.82	+05.67	XII	6.0					5	18	18.7	
6569	18 11.1	−31 50	00.49	−06.68	VIII	2.2	10.63		1.11		5		17.35	
6584	18 15.4	−52 14	342.14	−16.41	VIII	9.7	9.4	F7		+160	0			13
6624	18 21.1	−30 23	02.80	−07.92	VI	2.7	9.53	G2	1.00	+ 69				13
6626	18 22.1	−24 54	07.80	−05.59	IV	15.0	8.48	F9	0.97	+ 1	16	14.73	15.62	5
6637	18 28.8	−32 23	01.72	−10.26	V	3.8	8.94	G5	0.87	+ 95	5			7
6638	18 28.5	−25 32	07.90	−07.16	VI	2.2	10.24	G2	0.96	− 14		16.22		15
6642	18 29.0	−23 30	09.78	−06.34		0.8	10.3							
6652	18 33.2	−33 02	01.53	−11.38	VI:	2.3	9.86	G2	0.78	−124				16
6656	18 33.9	−23 58	09.87	−07.55	VII	17.0	6.48	F6	0.86	−144	24	12.93	14.15	3
Pal 8	18 39.1	−19 51	14.11	−06.79	X	1.6								
6681	18 40.7	−32 20	02.85	−12.52	V	4.1	8.95	G2	0.59	+198	2			20
6712	18 50.8	−08 46	25.34	−04.32	IX:	4.2	9.98	G2	1.04	−131	12	15.35	16.48	7
6715	18 52.6	−30 31	05.63	−14.11	III	5.5	8.74	F7	0.70	+122	80		17.4	17

TABLE I—*continued*

CATALOGUE OF 119 GLOBULAR CLUSTERS

No.	R.A. 1960	Dec.	l^{II}	b^{II}	Conc.	Ang. diam.	Int. mag.	Sp. type	Colour P–V	Rad. vel. km./sec.	No. vars.	Mag. 25 br. st.	App. mod.	D kpc.
	h m	° ′	°	°		′								
6717	18 52.7	−22 46	12.86	−10.91	VIII	2.6						16		
6723	18 56.9	−36 41	00.07	−17.30	VII	7.5	7.75	G3	0.61	− 3	19	14.20	15.34	10
6752	19 07.3	−60 03	336.49	−25.62	VI	41.9	7.2	F6		− 39	1	13.26	14.2	6
6760	19 09.1	+00 58	36.10	−03.91	IX:	2.4	11.25		1.55		4	16.77	17.45	4
6779	19 15.0	+30 06	62.65	+08.34	X	5.0	9.55	F5	0.74	−145	12	15.31	16.3	13
Pal 10	19 16.4	+18 29	52.44	+02.68	XII	3.1						20		
6809	19 37.5	−31 02	08.83	−23.28	XI	14.8	7.08		0.55	+170	6	13.58	14.5	6
Pal 11	19 43.1	−08 08	31.79	−15.60	XI	2.8					0	17		
6838	19 51.9	+18 41	56.74	−04.55		6.1	8.3	G2	0.95	− 80	4	14.82	14.6	5
6864	20 03.8	−22 02	20.31	−25.76	I	4.6	9.50	G1	0.71	−198	11	17.06	18.1	29
6934	20 32.2	+07 16	52.10	−18.88	VIII	6.2	10.01	F9	0.62	−360	51	15.78	16.9	19
6981	20 51.2	−12 42	35.15	−32.68	IX	5.1	10.24	G2	0.57	−255	39	15.86	17.0	21
7006	20 59.6	+16 02	63.77	−19.39	I	2.2	11.45	F1	0.61	−348	49	17.1	18.8	49
7078	21 28.1	+12 00	65.02	−27.32	IV	12.3	7.33	F3	0.59	−107	103	14.31	15.9	13
7089	21 31.4	−01 00	53.37	−35.78	II	11.7	7.30	F3	0.57	− 5	17	14.61	16.2	15
7099	21 38.1	−23 22	27.16	−46.83	V	8.9	8.58	F3	0.48	−174	4	14.63	15.54	12
Pal 12	21 44.3	−21 25	30.52	−47.64	XII	2.1					3	17		
Pal 13	23 04.7	+12 31	87.07	−42.72	XII	4.0					4	19		34
7492	23 06.2	−15 51	53.32	−63.46	XII	4.3	12.33				1	16.82	17.9	33

Objects not included in Table I

	R.A. 1950	Dec.	Reference
	h m	° ′	
NGC 2158	06 04.4	+24 06	van den Bergh, S., and Sher, D. *Dunlap Pub.*, v. 2, no. 7, p. 203, 1960.
Melotte 66	07 24.8	−47 38	Eggen, O. J., and Stoy, R. H. *Roy. Obs. Bull.*, no. 53, 1962.
Bjurakan Object	10 52.0	+40 44	Kinman, T. D., and Rosino, L. *A. S. P. Pub.*, v. 74, p. 499. (See Section A.)
Anon. Object	17 45.7	−60 45	Sawyer, H. B. *Dunlap Pub.*, v. 2, no. 2, p. 36, 1955.
NGC 6684	18 44.1	−65 14	*Ibid.*
NGC 6749	19 02.6	+01 48	Setteducati, A. F., and Weaver, H. F. *Newly Found Star Clusters*, I. Radio Ast. Lab., Univ. of Cal. 1960.

Reference Sources

The main sources of information for the respective columns in the catalogue are as follows: concentration class, Shapley and Sawyer, *Harv. Bull.*, no. 849, 1927; apparent diameter, Mowbray, *Ap. J.*, v. 104, p. 47, 1947, and Shapley and Sayer, *Harv. Repr.*, no. 116, 1935; integrated photographic magnitudes, Christie, *Ap. J.*, v. 91, p. 8, 1940, and Sawyer and Shapley, *Harv. Bull.*, no. 848, 1927; spectral type, Mayall, *Ap. J.*, v. 104, p. 290, 1946, Morgan, *A. S. P. Pub.*, v. 68, p. 509, 1956, Kinman, *M. N.*, v. 119, p. 553, 1959; colours, Kron and Mayall, *A. J.*, v. 65, p. 590, 1960; radial velocities, Mayall, *op. cit.*, and Kinman, *M. N.*, v. 119, p. 171, 1959; variables, Sawyer Hogg, *Bamberg Kl. Veröff.*, no. 34. 1962; magnitude of 25 brightest stars from miscellaneous sources; distance in kiloparsecs is an average of three nearly simultaneous determinations, (when available) Kinman, *M. N.*, v. 119, p. 171, 1959, Sawyer Hogg, *Hd. der Ap.*, v. 53, p. 205, 1959, Kron and Mayall, *A. J.*, v. 65, p. 605, 1960. More accurate values for the above quantities are available for short lists of clusters, but the aim has been to keep this catalogue as homogeneous as possible throughout.

Columns 2 and 3 give the right ascension and declination for the epoch of 1960. (This is to provide a usable position for telescopes at present. Positions for the epoch of 1950 can be found in Section A.) Columns 4 and 5 are the galactic longitude and latitude on the new standards. Successive columns then give concentration class, apparent diameter, integrated magnitude, spectral type, colour, radial velocity, number of variable stars, magnitude of the 25 brightest stars, apparent modulus, and the distance in kiloparsecs.

The footnotes to the table list certain clusters which have been dropped from the list of globular clusters, with references which give the reason for this. They also list references from which most of the material in the catalogue is derived. In the case of some clusters, however, the reader can obtain values from the material indexed in Section A.

IV. Acknowledgments

The reference sources for this publication were practically all available in the libraries of the David Dunlap Observatory and the University of Toronto. A few items, however, were obtained from the libraries of the Dominion Observatory, the Dominion Astrophysical Observatory and the National Research Council at Ottawa. It is a pleasure to acknowledge my debt to the librarians of these institutions for their help in locating references, especially to Mrs. Nancy McKenzie and Mrs. Jean Lehmann of the David Dunlap Observatory, and to Mrs. Joan Topley for preparing the final copy for the printer.

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Richmond Hill, Ontario
August 15, 1963

SECTION A

References for Individual Clusters

α and δ for 1950

NGC 104 (47 Tucanae) $\alpha\ 00^h\ 21^m.9$, $\delta\ -72°\ 21'$ $l^{II}\ 305°.89$, $b^{II}\ -44°.90$

1908 Leavitt, H. S. 1777 variables in the Magellanic Clouds. *Harv. Ann.*, v. 60, no. 4. (Announcement of HV 810, 811, 812, 813, 814).

1951 McKibben-Nail, V. Variables in the globular cluster 47 Tucanae. *Harv. Bull.*, no. 920.

1957 Gascoigne, S. C. B., and Burr, E. J. Surface photometry of the globular clusters 47 Tucanae and Omega Centauri. *M. N.*, v. 116, pp. 570–582.

1958 Thackeray, A. D. 47 Tucanae—an interim report. *Radcliffe Repr.*, no. 11, from "Semaine d'Etude sur le Problème des Populations Stellaires," *L'Acad. Pontif. Sci.*, no. 16; *Ric. Astr. Vaticano*, v. 5, pp. 69–73.

1959 Gaposchkin, S. I. On two brightest globular clusters. *A. J.*, v. 64, p. 331.

1960 Feast, M. W., Thackeray, A. D., and Wesselink, A. J. 47 Tucanae: the membership of two RR Lyrae variables. *M. N.*, v. 120, p. 64. First reference, T. D. Kinman, *M. N.*, v. 119, p. 575, 1959.

1960 Feast, M. W., and Thackeray, A. D. 47 Tucanae: radial velocities and spectral types of individual stars. *M. N.*, v. 120, no. 5, pp. 463–482, with plates.

1961 Crampin, J., and Hoyle, F. On the change with time of the integrated colour and luminosity of an M 67-type star group. *M. N.*, v. 122, pp. 27–33; Summ., *Quarterly Jour.*, v. 2, no. 3, p. 213.

1961 Eggen, O. J. Three colour photometry of red variables. *Roy. Obs. Bull.*, no. 29.

1961 Hogg, A. R. Galactic clusters. *Australian Scientist*, v. 1, no. 4, pp. 217–224, with photo.

1961 Kron, G. E. The unusual colors of two globular clusters of the Magellanic Clouds. *A. S. P. Pub.*, v. 73, pp. 202–205.

1961 Wildey, R. L. The color-magnitude diagram of 47 Tuc. *Ap. J.*, v. 133, pp. 430–437, with plate.

1928*a* Ludendorff, 1928 Shapley, 1935 Walters, 1947*abd* Sawyer, 1947*abde* Parenago, Kukarkin, Florja, 1949*cefh* Shapley, 1950*b* Becker, 1951*ae* Payne-Gaposchkin, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953*di* Rosino, 1954 Cimino, 1954*a* Payne-Gaposchkin, 1954*b* Rosino, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1955*Ia, IId* Struve, 1956*c* Baum, 1956*a* Schmidt, 1956 Woolley, 1957 Stohl, 1957 Woolley and Robertson, 1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1958*I, II* Kinman, 1958*b* Ledoux and Walraven, 1958*Ic, II* Sawyer Hogg, 1959*Iad, IIabei, III* Kinman, 1959*b* Larsson-Leander, 1959 Matsunami *et al.*, 1959*Ibeikmop, IIcd, III* Sawyer Hogg, 1959*ab* Thackeray, 1960 Feast, Thackeray, Wesselink, 1960 Gingerich, 1960 Sandage and Wallerstein, 1960*bceg* Wilkens, 1961*a* Haffner, 1961 Hénon, 1961 Lohmann, 1961 Kurochkin, 1961 Michie, 1961 Poveda, 1961*I, IIb, III* Sawyer Hogg, 1961 Woolley, 1961*I, II* Woolley and Dickens, 1962 Aller, 1962*IIb* Arp, 1962 van den Bergh, 1962 Fernie, 1962 King, 1962 Kinman, 1962 Michie, 1962 Sawyer Hogg.

See also: 7078 1961 King, 6838 1961 Stephenson, 104 1961 Wildey, 5139 1962 Fehrenbach and Duflot, 6712 1962 Smith and Sandage.

NGC 288 $\alpha\ 00^h\ 50^m.2,\ \delta - 26°\ 52'$ $l^{II}149°.66,\ b^{II} - 89°.40$

1921*II* Gregory, 1947*abd* Sawyer, 1948*I* Sawyer, 1949*abcde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*d* Rosino, 1954 Cuffey, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1955*IIc* Struve, 1956*c* Baum, 1956*a* Schmidt, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959 Johnson, 1959*Iad, IIa* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*bcg* Wilkens, 1961 Hénon, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 362 $\alpha\ 01^h 00^m.6,\ \delta - 71°\ 07'$ $l^{II}301°.64,\ b^{II} - 46°.25$

1935 Walters, 1947*abd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953*d* Rosino, 1954 Cimino, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*a* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1958*I* Sandage, 1959 van Agt and Oosterhoff, 1959*Iad, IIbi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*bcg* Wilkens, 1961 Kurochkin, 1961 Payne-Gaposchkin, 1961*I* Sawyer Hogg, 1962 Aller, 1962 Fernie, 1962 Sawyer Hogg.

NGC 1261 $\alpha\ 03^h 10^m.9,\ \delta - 55°\ 25'$ $l^{II}270°.56,\ b^{II} - 52°.12$

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabc* Lohmann, 1953 Dreyer, 1953*d* Rosino, 1954 Cuffey, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*c* Baum, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959*Iacd, IIci* Kinman, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens, 1962 Fernie.

Palomar 1 $\alpha\ 03^h 25^m.7,\ \delta + 79°\ 28'$ $l^{II}130°.02,\ b^{II} + 19°.06$

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory Sky Survey. *A. S. P. Pub.*, v. 67, pp. 258–261. (Discovery by Abell).

1962 Kinman, T. D., and Rosino, L. Notes on faint star clusters. *A. S. P. Pub.*, v. 74, pp. 499–506.

1958 Alter, Ruprecht, Vanýsek, 1958 van den Bergh, 1958 Burbidge and Sandage, 1958 Heckmann, 1959*Ip* Sawyer Hogg, 1961*III* Sawyer Hogg, 1962*I* Rosino.

Palomar 2 $\alpha\ 04^h\ 43^m.1,\ \delta + 31°\ 23'$ $l^{II}170°.49,\ b^{II} - 08°.98$

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory Sky Survey. *A. S. P. Pub.*, v. 67, pp. 258–261. (Discovery by A. G. Wilson).

1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1959 *Ip* Sawyer Hogg, 1962*I* Rosino.

NGC 1841 $\alpha\ 04^h\ 52^m.5,\ \delta - 84°\ 05'$ $l^{II}297°.02,\ b^{II} - 30°.15$

1947*abd* Sawyer, 1949*b* Shapley, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*c* Baum, 1958 Alter, Ruprecht, Vanýsek, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens.

NGC 1851 $\alpha\ 05^h\ 12^m.4,\ \delta - 40°\ 05'$ $l^{II}244°.49,\ b^{II} - 35°.05$

1912 Knox Shaw, 1928*a* Ludendorff, 1947 Parenago, 1947*abd* Sawyer, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*d* Rosino, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*c* Baum, 1956*ab* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959 Dzigvashvili, 1959*Iabd, IIbi* Kinman, 1959 Matsunami *et al.*, 1959*Iip, III* Sawyer Hogg, 1960 Kurth, 1960*bd* Wilkens, 1962 Fernie, 1962 Sawyer Hogg.

NGC 1904 (Messier 79) $\alpha\ 05^h\ 22^m.2$, $\delta - 24°\ 34'$ $l^{II}227°.23$, $b^{II} - 29°.33$

1952 Rosino, L. Ricerche sugli ammassi globulari VIII. Stelle variabili e distanza dell' ammasso globulare NGC 1904 = M 79. *Univ. Bologna Oss. Pub.*, v. V, no. 20; *Soc. Astr. Ital. Mem.*, v. 23, pp. 101–107.

1947 Parenago, 1947*abcd* Sawyer, 1948*b* Perek, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953*i* Rosino, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*b* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1959 van Agt and Oosterhoff, 1959 Dzigvashvili, 1959*Iabd*, *IIbi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960 Kurth, 1960*b* Roberts, 1960*bcg* Wilkens, 1961 Hénon, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 2298 $\alpha\ 06^h\ 47^m.2$, $\delta - 35°\ 57'$ $l^{II}245°.63$, $b^{II} - 16°.01$

1947 Parenago, 1947*abd* Sawyer, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd*, *II* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960 Kurth, 1960*bd* Wilkens, 1962 Fernie, 1962 Sawyer Hogg.

NGC 2419 $\alpha\ 07^h\ 34^m.8$, $\delta + 39°\ 00'$ $l^{II}180°.37$, $b^{II} + 25°.25$

1959 de Vaucouleurs, G. Magnitudes and colors of galaxies in the UBV system. *Lowell Bull.*, v. 4, no. 97, p. 105.

1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*abde* Parenago, Kukarkin, Florja, 1949*bcde* Shapley, 1952*Iabd*, *IIIc* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953*cd* Rosino, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*b* Schmidt, 1957 van den Bergh, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958 Náprstková, 1958*Ib* Sawyer Hogg, 1959 Dzigvashvili, 1959 Johnson, 1959*Id*, *IIi*, *III* Kinman, 1959 Matsunami *et al.*, 1959*Ibdip*, *IIe* Sawyer Hogg, 1960*acfhikl* Kron and Mayall, 1960 Kurth, 1960*b* Roberts, 1960*acef* Wilkens, 1961 Hénon, 1961 Kurochkin, 1961*I*, *IIb* Sawyer Hogg, 1961 Sharov and Pavlovskaya, 1962 Fernie, 1962 Kinman, 1962 Rosino and Sawyer Hogg, 1962 Sawyer Hogg.

See also: 7006 1954 Sandage.

NGC 2808 $\alpha\ 09^h\ 10^m.9$, $\delta - 64°\ 39'$ $l^{II}282°.18$, $b^{II} - 11°.26$

1947*abd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959*Iad*, *IIbei* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*bcg* Wilkens, 1962 Aller, 1962 Fernie, 1962 Sawyer Hogg.

Palomar 3 $\alpha\ 10^h\ 03^m.0$, $\delta + 00°\ 18'$ $l^{II}240°.16$, $b^{II} + 41°.86$

1955 Wilson, A. G. Sculptor-type systems in the local group of galaxies. *A. S. P. Pub.*, v. 67, pp. 27–29. (Discovery by Baade and Wilson independently).

1958 Burbidge, E. M., and Sandage, A. Properties of two intergalactic globular clusters. *Ap. J.*, v. 127, pp. 527–538, with plate. Ref., E. Opik, *Irish A. J.*, v. 5, p. 118, 1958.

1955 Abell, 1958 Alter, Ruprecht, Vanýsek, 1958*c* Burbidge and Burbidge, 1958 Heckmann, 1958*Ib* Sawyer Hogg, 1959*Idp*, *III* Sawyer Hogg, 1961*III* Sawyer Hogg, 1962 Kinman, 1962 Sawyer Hogg.

See also: Pal 1 1962 Kinman and Rosino.

NGC 3201 α 10h 15m.5, δ − 46° 09′ l^{II} 277°.21, b^{II} + 08°.64

1953 Kholopov, P. N. Space distribution of RR Lyrae variables in the globular clusters M 5 and NGC 3201. *Var. Stars.* (Russ.), v. 9, pp. 371–378. Ref. *Ast. News Letter* no. 82, 1956.

1956 Kreiken, E. A. A statistical study of pulsating stars. V. The variable stars in M 53 and NGC 3201. *Fac. Sci. Univ. Ankara Comm.*, v. 8, p. 67; *Dept. Astron. Ankara Comm.*, no. 12.

1928*a* Ludendorff, 1947*abd* Sawyer, 1948*I* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1955*IIa* Struve, 1956 van den Bergh, 1956 Kourganoff, 1956*a* Schmidt, 1957 van den Bergh, 1957 Kholopov, 1958 Alter, Ruprecht, Vanýsek, 1958 Kholopov, 1958*I*, *II* Kinman, 1958*I* Sandage, 1958*II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959*Iad*, *IIad*, *III* Kinman, 1959 Kurochkin, 1959 Matsunami *et al.*, 1959 Preston, 1959*Iip* Sawyer Hogg, 1960 Pavlovskaya, 1960*acf* Wilkens, 1961 Payne-Gaposchkin, 1961*I*, *III* Sawyer Hogg, 1961 Sharov and Pavlovskaya, 1962 Fernie, 1962 Sawyer Hogg.
See also: 5272 1955 Kholopov.

Bjurakan Object 10h 52m.0, +44° 44′ l^{II} 176°.39, b^{II} + 62°.53

1957 Shakhbazian, R. K. On a star cluster in the Big Dipper. *Ast. Circ.*, (Russ.), no. 177, pp. 11–12.

1961 Rosino, L. Notizie su un debole ammasso stellare e su un remotissimo ammasso di galassie. *Padova Comm.*, no. 22; *Accad. Patavina SS LL AA Cl. Sci. Mat. Nat. Mem.*, v. 73, 1960–61.

1962 Kinman, T. D., and Rosino, L. Notes on faint star clusters. *A.S.P. Pub.*, v. 74, pp. 499–506. Not a globular cluster.

1958 Heckmann, 1958*Ib* Sawyer Hogg, 1959*Idp* Sawyer Hogg, 1961*III* Sawyer Hogg, 1962*I* Rosino.

Palomar 4 α 11h 26m.6, δ + 29° 15′ l^{II}202°.31, b^{II} + 71°.80

1955 Wilson, A. G. Sculptor-type systems in the local group of galaxies. *A. S. P. Pub.*, v. 67, pp. 27–29. (Discovery by Hubble and Wilson independently).

1956 van den Bergh, S. Note on the globular cluster Abell No. 4. *A. S. P. Pub.*, v. 68, pp. 449–450. Summ., *Sky and Tel.*, v. 16, p. 176, 1957.

1957 Rosino, L. Sopra due ammassi globulari del catalogo di Abell. (No. 4 e No. 13). *Asiago Cont.*, no. 85, with plate.

1958 Burbidge, E. M., and Sandage, A. Properties of two intergalactic globular clusters. *Ap. J.*, v. 127, pp. 527–538, with plate. Ref., E. Opik, *Irish A. J.*, v. 5, p. 118, 1958.

1955 Abell, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958 van den Bergh, 1958*c* Burbidge and Burbidge, 1958 Heckmann, 1958*Ib*, *II* Sawyer Hogg, 1959*Idp*, *IIe*, *III* Sawyer Hogg, 1961*I*, *III* Sawyer Hogg, 1962 Kinman, 1962*I* Rosino, 1962 Sawyer Hogg.
See also: Bjurakan 1957 Shakhbazian.

NGC 4147 α 12h 07m.6, δ + 18° 49′ l^{II}252°.89, b^{II} + 77°.19

1955 Sandage, A. R., and Walker, M. F. The globular cluster NGC 4147. *A. J.*, v. 60, pp. 230–236.

1957 Newburn, R. L. Jr. The RR Lyrae stars in NGC 4147. *A. J.*, v. 62, pp. 197–203.

NGC 4147 (cont'd)

1958 Mannino, G. Periodi e curve di luce di sei variabili dell' ammasso globulare NGC 4147. Nota I and Nota II. *Soc. Astr. Ital. Mem.*, v. 29, no. 1, pp. 139–143; *Asiago Cont.*, no. 87.

1928*a* Ludendorff, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948 Gamalej, 1948*b* Perek, 1949*abcde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953*d* Rosino, 1954 Blamont, 1954 Cuffey, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*ac* Baum, 1956 van den Bergh, 1956*b* Schmidt, 1957 van den Bergh, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958*bh* Arp, 1958*bc* Burbidge and Burbidge, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1958*I* Sandage, 1958*Ie*, *II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959*c* Arp, 1959 Dzigvashvili, 1959*Id*, *IIaji* Kinman, 1959 Matsunami *et al.*, 1959*Ibdfip*, *IIc*, *III* Sawyer Hogg, 1960 Eggen, 1960*III* Hodge, 1960*acfgijk* Kron and Mayall, 1960 Kurth, 1960*h* Roberts, 1960 Sandage and Wallerstein, 1960*acf* Wilkens, 1961*b* Haffner, 1961 Hénon, 1961*I*, *III* Sawyer Hogg, 1962*I* Arp, 1962 Fernie, 1962 Kinman, 1962 Sawyer Hogg.

See also: 5272 1956 Baker and Baker; 5272 1956 Johnson and Sandage.

NGC 4372 α 12ʰ 23ᵐ.0, δ − 72° 24′ l^{II}301°.01, b^{II} − 09°.90

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1951*b* Bok (photo), 1951 Thackeray, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958 Kinman, 1958*II* Sawyer Hogg, 1959*Iad*, *IIa* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*bd* Wilkens, 1961*a* Haffner, 1961*I*, *III* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 4590 (Messier 68) α 12ʰ 36ᵐ.8, δ − 26° 29′ l^{II}299°.62, b^{II} + 36°.04

1938 Luyten, W. J. Bruce proper motion survey. II. A catalogue of 2350 variable stars found with the blink microscope. *Obs. Univ. Minnesota Pub.*, v. II, no. 6. (HV 8460 = FI Hya).

1948 Long period variable and M 68. *B. A. A. Jour.*, v. 58, p. 196.

1953 Rosino, L., Pietra, S. Periodi e curve di luce di stelle variabili nell' ammasso globulare NGC 4590 = M 68. Nota 1. *Soc. Astr. Ital. Mem.*, v. XXIV, no. 4.

1954 Rosino, L., Pietra, S. Ricerche sugli ammassi globulari X. Periodi e curve di luce di 24 stelle variabili nell' ammasso globulare NGC 4590 = M 68. *Univ. Bologna Oss. Pub.*, v. VI, no. 5.

1959 van Agt, S. L. Th., and Oosterhoff, P. Th. Observations of variable stars in the globular clusters NGC 4590 (M 68) and NGC 6266 (M 62). *Leiden Ann.* v. XXI, 4th pt., pp. 253–290, with plates.

1912 Knox Shaw, 1928*a* Ludendorff, 1947 Parenago, 1947*abcd* Sawyer, 1948*b* Perek, 1948*I* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1949*cde* Shapley, 1951 Thackeray, 1952*Iabd*, *II* Lohmann, 1953 Dreyer, 1954 Blamont, 1954 Gingerich, 1954 Perek, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*ab* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *IIi* Kinman, 1958 Maffei (photo), 1958*II* Sawyer Hogg, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*Ifip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960 Kurth, 1960*acf* Wilkens, 1961 Kurochkin, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

See also: 6838 1956 Artjuchina.

NGC 4833 α 12ʰ 56ᵐ.0, δ − 70° 36′ l^{II}303°.59, b^{II} − 08°.01

1928*b* Ludendorff, 1947*abd* Sawyer, 1948*I* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabcd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1956

NGC 4833 (cont'd)

van den Bergh, 1956 Kreiken, 1956*a* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 van Agt and Oosterhoff, 1959*Iad*, *IIa* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*bcg* Wilkens, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 5024 (Messier 53) α 13^h 10^m.5, δ + 18° 26′ l^{II}333°.00, b^{II} + 79°.76

1956 Kreiken, E. A. A statistical study of pulsating stars. V. The variable stars in M 53 and NGC 3201. *Fac. Sci. Univ. Ankara Comm.*, v. 8, p. 67; *Dept. Astron. Ankara Comm.*, no. 12.

1957 Cuffey, J. Color-magnitude relations in Messier 53 and NGC 7492. *A. J.*, v. 62, p. 91.

1958 Cuffey, J. Color indices in M 53. *Ap. J.*, v. 128, pp. 219–227; *Goethe Link Pub.*, no. 24.

1962 Cuffey, J. Variable star search in M 53. *A. J.*, v. 67, p. 574.

1928*ab* Ludendorff, 1938*a* Payne-Gaposchkin and Gaposchkin, 1946 Miczaika, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948 Gamalej, 1948*b* Perek, 1948*I* Sawyer, 1949*abcde* Parenago, Kukarkin, Florja, 1949*cef* Shapley, 1950*dg* Becker, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Gingerich, 1953 Kholopov, 1953 Lohmann, 1953*acdei* Rosino, 1954 Blamont, 1954 Cuffey, 1954 Gingerich, 1954*b* Rosino, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*c* Morgan, 1956*b* Schmidt, 1957 van den Bergh, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958*be* Arp, 1958 Heckmann, 1958*I*, *II* Kinman, 1958*I* Sandage, 1958*II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959 Dzigvashvili, 1959*Id*, *IIai* Kinman, 1959 Kurochkin, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959 Preston, 1959*Iikp*, *III* Sawyer Hogg, 1960*abcdfik* Kron and Mayall, 1960 Kurth, 1960*bh* Roberts, 1960 Sandage and Wallerstein, 1960*acf* Wilkens, 1961*ab* Haffner, 1961 Hénon, 1961 Lohmann, 1961 Payne-Gaposchkin, 1961*I*, *III* Sawyer Hogg, 1962*I* Arp, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 5053 α 13^h 13^m.9, δ + 17° 57′ l^{II}335°.55, b^{II} + 78°.95

1949 Rosino, L. Ricerche sugli ammassi globulari. II. Sui periodi e curve di luce di 10 stelle variabili appartenenti all'ammasso globulare NGC 5053. *Univ. Bologna Oss. Pub.*, v. V, no. 10 (photo).

1947*abd* Sawyer, 1948*I*, *II* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*de* Rosino, 1954 Cuffey, 1954 Markarian, 1954*a* Payne-Gaposchkin, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956 Kreiken, 1956*a* Schmidt, 1957 van den Bergh, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958 Burbidge and Sandage, 1958*I* Kinman, 1958 Maffei (photo), 1959 van Agt and Oosterhoff, 1959*IIa* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960 Bowen, 1960 Ikhsanov, 1960*acfik* Kron and Mayall, 1960 Sandage and Wallerstein, 1960*acf* Wilkens, 1961*a* Haffner, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 King, 1962 Sawyer Hogg.

See also: Pal 5 1951 Rosino, 6779 1951 Rosino, 5024 1958 Cuffey, 7492 1961 Cuffey.

NGC 5139 (Omega Centauri) α 13^h 23^m.8, δ − 47° 13′ l^{II}309°.10, b^{II} + 14°.97

1948 van Gent, H., Oosterhoff, P. Th. Provisional elements and light-curves of the variables 133 and 159 in ω Cen. *B. A. N.*, v. 10, pp. 377–382.

1952 Kholopov, P. N. The ellipticity of globular clusters. *A. J. UdSSR*, v. 29, no. 6, pp. 671–681.

NGC 5139 (cont'd)

1953 Kholopov, P. N. Die räumliche Verteilung der RR Lyrae-Sterne im kugelförmigen Sternhaufen ω Centauri. *A. J. UdSSR*, v. 30, no. 4, pp. 426–441.
1955 FitzGerald, A. P. Note on globular cluster Omega Centauri. *Irish A. J.*, v. 3, p. 204; *Armagh Leaflet*, no. 38. (Plate 17, photo of cluster showing nebulosity).
1956 Ege, D. A statistical study of pulsating stars. 14th paper. Irregular variables in ω Centauri. *Fac. Sci. Ankara Comm.*, v. 8, no. 1; *Dept. Astron. Ankara Univ. Comm.*, no. 21.
1956 Kreiken, E. A. A statistical study of pulsating stars. 1st paper. The variable stars in ω Centauri. *Fac. Sci. Ankara Comm.*, v. 8, p. 40; *Dept. Astron. Ankara Comm.*, no. 8.
1956 Lindsay, E. M. The dimensions of Omega Centauri. *Armagh Cont.* no. 20; repr. from *Vistas in Astronomy*, A. Beer, ed., vol. 2 (two photos).
1957 Gascoigne, S. C. B., and Burr, E. J. Surface photometry of the globular clusters 47 Tucanae and Omega Centauri. *M. N.*, v. 116, pp. 570–582.
1958 Arp, H. C. Southern hemisphere photometry. II. Photoelectric measures of bright stars. *A. J.*, v. 63, p. 118, with plate.
1959 Belserene, E. P. Magnitudes and colors in ω Centauri. *A. J.*, v. 64, pp. 58–64.
1959 Gaposchkin, S. I. On two brightest globular clusters. *A. J.*, v. 64, p. 331.
1959 Kinman, T. D. A note on the RR Lyrae variables. *M. N.*, v. 119, p. 134.
1960 Thackeray, A. D. A W Vir variable in Omega Centauri. *Obs.*, v. 80, pp. 226–227.
1961 Belserene, E. Pisani. Changes in the periods of RR Lyrae stars in Omega Centauri. *A. J.*, v. 66, p. 38; Ref., *Urania, Krakow*, v. 32, pp. 310–311.
1961 Eggen, O. J. Three colour photometry of red variables. *Roy. Obs. Bull.*, no. 29.
1961 Harding, G. A. A CH star in ω Centauri. *Obs.*, v. 82, no. 930, pp. 205–207, with plate.
1961 King, I. The shape of a rotating star cluster. *A. J.*, v. 66, pp. 68–70.
1961 Ponsen, J. On the absence of δ Scuti-type variables in ω Centauri. *B. A. N.*, v. 15, p. 326.
1962 Fehrenbach, C., and Duflot, M. Deux étoiles à grande vitesse découvertes dans le ciel austral. *European Southern Obs. Comm.*, no. 2.

1928*a* Ludendorff, 1935 Walters, 1938*abd* Payne-Gaposchkin and Gaposchkin, 1940 Shapley and Paraskevopoulos, 1943 Payne-Gaposchkin, Brenton, Gaposchkin, 1946 Miczaika, 1947*ab* (error in Dec.) *d* Sawyer, 1948*I* Sawyer, 1949 Gialanella, 1949 Joy, 1949 Kholopov, 1949*abde* Parenago, Kukarkin, Florja, 1949*cefgh* Shapley, 1950*bceg* Becker, 1950 Shapley, 1951*a* Bok (photo), 1951*abd* Payne-Gaposchkin, 1952 Kholopov, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953*adegi* Rosino, 1953 Shapley and McKibben, 1954 Belserene, 1954*ab* Payne-Gaposchkin, 1954*b* Rosino, 1954 Woolley, 1954*I* Zagar, 1955*I* Arp, 1955*I*, *IIbcd* Sawyer, 1955*Ia*, *IId* Struve, 1956 Baum, 1956 van den Bergh, 1956 Kourganoff, 1956*c* Morgan, 1956*a* Schmidt, 1956 Woolley and Robertson, 1957 van den Bergh, 1957*II* von Hoerner, 1957 Kholopov, 1957 Poveda, 1957 Rosino, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*ek* Arp, 1958 Heckmann, 1958 Kholopov, 1958*I*, *II* Kinman, 1958*a* Ledoux and Walraven, 1958 Náprstková, 1958*I* Sandage, 1958*Ih*, *II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959*Iabd*, *IIaci* Kinman, 1959 Kurochkin, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959 Payne-Gaposchkin, 1959 Preston, 1959 Sandage, 1959*Iabceimop* (error in Dec.) *IIacd*, *III* Sawyer Hogg, 1960 Eggen, 1960 Gingerich, 1960 Pavlov-

NGC 5139 (cont'd)

skaya, 1960*a* Roberts, 1960*acf* Wilkens, 1961 van den Bergh. 1961*a* Haffner, 1961 Hénon, 1961 Kurochkin, 1961 Lohmann, 1961 Michie, 1961 Payne-Gaposchkin, 1961 *I, III* Sawyer Hogg, 1961 Woolley, 1961*II* Woolley and Dickens, 1962 Aller, 1962*IIbc* Arp, 1962 Fernie, 1962 King, 1962 Kinman, 1962*II* Rosino, 1962*I* Sandage, 1962 Sawyer Hogg.

See also: 5053 1949 Rosino, 7078 1955 Kholopov, 3201 1956 Kreiken, 5272 1956 Kreiken, 5904 1956 Kreiken, 7078 1959 Bronkalla, 5272 1959 Oort and van Kerk, 7078 1961 King.

NGC 5272 (Messier 3) α 13^h 39^m.9, δ + 28° 38′ l^{II}42°.24, b^{II} + 78°.70

1922 Graff, K. Ueber sekundäre Wellen in den Lichtkurven der Sterne vom δ Cephei-typus. *A. N.*, v. 217, p. 310.

1922 Lindblad, B. Spectrophotometric methods for determining stellar luminosity. *Ap. J.*, v. 55, pp. 85–118; *Mt. W. Cont.*, no. 228.

1927 Schilt, J. The short-period variable star RV Canum Venaticorum. *Ap. J.*, v. 65, p. 124; *Mt. W. Cont.*, no. 330.

1947 Kholopov, P. N. The relative masses of the stars in the globular cluster M3. *A. J. UdSSR*, v. 24, p. 45.

1947 Lohmann, W. Die Masse der kugelförmigen Sternhaufen M 3 und M 13. *Z. f. Naturforschung*, v. 2a, p. 477; *Stern. Königstuhl-Heidelberg Mitt.*, no. 49.

1950 Vandekerkhove, E. Etude d'amas résultants. *Obs. Roy. Belgique Comm.*, no. 18, pp. 23–26.

1952 Arp, H. C., Baum, W. A., and Sandage, A. R. The H-R diagrams for the globular clusters M 92 and M 3. *A. J.*, v. 57, pp. 4–5.

1952 Belserene, E. Pisani. Period changes of variable stars in Messier 3. *A. J.*, v. 57, pp. 237–247.

1952 Kholopov, P. N. The ellipticity of globular clusters. *A. J. UdSSR*, v. 29, no. 6, pp. 671–681.

1952 Schopp, J., and Schwarzschild, M. Note on the color-magnitude diagram of Messier 3. *A. J.*, v. 57, pp. 61–63.

1953 Kholopov, P. N. La répartition spatiale des étoiles de types divers dans l'amas globulaire M3. *A. J. UdSSR*, v. 30, pp. 517–531.

1953 Rabe, W. Astronomisches Tagebuch. *Sternenwelt*, v. 5, p. 65. (200-inch photo of outer region).

1953 Sandage, A. R. Interpretation of color-magnitude arrays in globular clusters. *Symposium on Astrophysics, University of Michigan.*

1953 Sandage, A. The color-magnitude diagram for the globular cluster M 3. *A. J.*, v. 58, pp. 61–75. Ref., *Sky and Tel.*, v. 13, p. 53, 1953.

1954 Roberts, M., and Sandage, A. Group characteristics of the RR Lyrae stars in M 3. *A. J.*, v. 59, p. 190. Summ., *Sky and Tel.*, v. 13, p. 220, 1954.

1954 Sandage, A. R. The luminosity function for the globular cluster M 3. *A. J.*, v. 59, pp. 162–168.

1954 Undersökningar av de klotformiga stjarnhoparna M 3 och M 92. *Pop. A. Tids.*, v. 35, pp. 76–78.

1955 Arp, H. C. Cepheids of periods greater than one day in globular clusters. *A. J.*, v. 60, pp. 1–17.

NGC 5272 (cont'd)

1955 Kholopov, P. N. The structure of the system of bright stars contained in the globular cluster M 3. *A. J. UdSSR*, v. 32, pp. 309–313.

1955 Pismis, P. On the period-luminosity relation in cluster-type Cepheids. *A. S. P. Pub.*, v. 67, p. 253.

1955 Roberts, M., and Sandage, A. The region of instability for RR Lyrae stars in the color-magnitude diagram for M 3. *A. J.*, v. 60, p. 185.

1955 Walker, M. F. A search for variable stars of small amplitude in M 3 and M 92. *A. J.*, v. 60, pp. 197–202.

1955 Zbijenojato. M 3 u Lovačkim Psima. *Vasiona*, v. 3, p. 68 (Serbian). (Report on Sandage's work.)

1956 Baker, R. H., and Baker, H. V. Ultraviolet light-curves of selected variable stars in M 3. *A. J.*, v. 61, pp. 283–289.

1956 Burbidge, G. R. On cluster-type variables and magnetic fields. *Ap. J.*, v. 124, pp. 412–415.

1956 Johnson, H. L., and Sandage, A. R. Three-color photometry in the globular cluster M 3. *Ap. J.*, v. 124, pp. 379–389.

1956 Kreiken, E. A. A statistical study of pulsating stars. 4th paper. The variables in Messier 3. *Fac. Sci. Univ. Ankara Comm.*, v. VIII, no. 1; *Dept. Astron. Ankara Univ. Comm.*, no. 11.

1956 Vandekerkhove, E. L'effet d'une population de type II sur le rougissement d'une nébuleuse extragalactique. *Acad. Roy. Belgique. Cl. Sci. Bull.*, (5) v. 42, pp. 185–200; *Obs. Roy. Belgique Comm.*, no. 94.

1957 Johnson, H. L. The relation between U-B and absolute magnitude of F-type stars. *A. S. P. Pub.*, v. 69, pp. 404–408.

1957 Osvath, I. Ueber die Periodänderungen der Veränderlichen im Kugelsternhaufen M 3. Konferenz über Veränderliche Sterne, Budapest, 1956; *Stern. Ungar. Akad. Wiss. Mitt.*, no. 42.

1957 Sandage, A. Observational approach to evolution. III. Semi-empirical evolution tracks for M 67 and M 3. *Ap. J.*, v. 126, pp. 326–340.

1958 Reddish, V. C. Correlations in the deviations of magnitudes of stars in clusters. *Obs.*, v. 78, pp. 247–249.

1959 Eggen, O. J., and Sandage, A. R. Stellar groups. IV. The Groombridge 1830 group of high velocity stars and its relation to the globular clusters. *M. N.*, v. 119, pp. 255–277.

1959 Kinman, T. D. A note on the RR Lyrae variables. *M. N.*, v. 119, p. 134.

1959 Kukarkin, B. V., and Kukarkina, N. P. An investigation of variable stars in the globular cluster M 3 = NGC 5272. I, A catalogue of photographic magnitudes of 81 stars in the outer regions of the cluster. *Var. Stars* (Russ.), v. 12, no. 4, pp. 291–292.

1959 Kurochkin, N. Variable stars in large vicinities of the M 3 cluster. *Ast. Circ.* (Russ.), no. 205, pp. 14–16.

1959 Lamla, E. Ueber die spektrale Intensitätsverteilung und die Leuchtkraftverteilung von Sternsystemen. *Astrophys. Obs. Potsdam Mitt.*, no. 74; *A. N.* v. 285, no. 1, pp. 33–48.

1959 Oort, J. H., and van Kerk, G. Structure and dynamics of Messier 3. *B. A. N.*, v. 14, no. 491, pp. 299–321.

NGC 5272 (cont'd)

1959 Roberts, M. S. A search for neutral atomic hydrogen in globular clusters. *Nature*, v. 184, Supp. 20, pp. 1555–1556.

1959 Sandage, A. On the intrinsic colors of RR Lyrae stars in M 3. *Ap. J.*, v. 129, pp. 596–599.

1960 Kurochkin, N. E. New variable stars in the remote neighborhood of M 3. *Var. Stars* (Russ.), v. 13, no. 2, pp. 84–100.

1960 Kukarkin, B. V. Identification of two variables in globular cluster M 3. *Ast. Circ.* (Russ.), no. 216, p. 29.

1960 Oort, J. H., and van Kerk, G. Internal motions and density distribution in a globular cluster. *Ann. d'Ap.*, v. 23, no. 3, pp. 375–378.

1960 Whitford, A. E. Lick Observatory report. Globular clusters. *A. J.*, v. 65, p. 534. Star von Zeipel 1128, spectrum and radial velocity.

1961 Hoag, A. A. Cooled-emulsion experiments. *A. S. P. Pub.*, v. 73, pp. 301–308, photos.

1961 Kron, G. E. The unusual colors of two globular clusters of the Magellanic Clouds. *A. S. P. Pub.*, v. 73, pp. 202–205.

1961 Kukarkin, B. V., Kukarkina, N. P. A study of variable stars in the globular cluster M 3 = NGC 5272. *Var. Stars* (Russ.), v. 13, no. 4, pp. 239–247.

1961 Kukarkina, N. P., and Kukarkin, B. V. Variable stars with a Blazhko effect in the globular cluster M 3. *Var. Stars* (Russ.), v. 13, no. 5, pp. 309–316.

1961 Kurochkin, N. E. Investigation of stars in the neighbourhood of the globular cluster M 3. *Astr. Circ.* (Russ.), no. 219, pp. 26–29.

1961 Meinel, A. B. New frontiers of astronomical technology. *Science*, v. 134, p. 1165. (Cover, image orthicon of M 3).

1961 Preston, G. W. The calculation of pulsation constants for the RR Lyrae stars in M 3. *Ap. J.*, v. 133, pp. 29–38.

1961 Sandage, A. R. The ages of the open cluster NGC 188 and the globular clusters M 3, M 5, and M 13 compared with the Hubble time. *A. J.*, v. 66, p. 53.

1961 Smak, J. On the P-(B-V) relation for RR Lyrae stars in M 3. *Acta Astr.*, v. 11, no. 2, p. 123; *Warsaw Univ. Obs. Repr.*, no. 111.

1961 Woolf, N. J. The distribution of horizontal branch stars in the globular cluster M 3. *A. S. P. Pub.*, v. 73, p. 339.

1962 Sandage, A. The ages of M 67, NGC 188, M 3, M 5, and M 13 according to Hoyle's 1959 models. *Ap. J.*, v. 135, pp. 349–365.

1962 Woolf, N. J. A fuel supply limit to the age of the globular cluster M 3. *Ap. J.*, v. 135, pp. 644–646; *Lick Cont.*, no. 126.

1962 Woolf, N. J. Age of Messier 3. *A. J.*, v. 67, no. 5, p. 286.

1928*a* Ludendorff, 1935 Walters, 1936 Kuiper, 1938*ac* Payne-Gaposchkin and Gaposchkin, 1940 Oort, 1946 Miczaika, 1946 Vogt, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948 Gamalej, 1948 Maitre, 1948*b* Perek, 1948*I, II* Sawyer, 1949 Gialanella, 1949 Joy, 1949*abcde* Parenago, Kukarkin, Florja, 1949*acdef* Shapley, 1950*cdfg* Becker, 1950 Kurth, 1951*I, II* Kurth, 1951*acd* Payne-Gaposchkin, 1952 Baade, 1952 Camm, 1952 Kholopov, 1952*Iabd, IIIa* Lohmann, 1953*a* Deutsch, 1953 Kholopov, 1953 Lohmann, 1953*adehij* Rosino, 1953 Shapley and McKibben, 1954 Belserene, 1954 Bidelman, 1954 Blamont, 1954 Cimino, 1954 Cuffey, 1954 Gingerich, 1954*ab* Payne-Gaposchkin, 1954*ab* Rosino, 1954*abc* Sandage, 1954 Schwarzschild, 1954*I* Zagar, 1955*I, II* Arp, 1955 Baum, 1955 von Hoerner, 1955 Hoyle and Schwarzschild, 1955*I, II* Reddish, 1955*I, IIbcd* Sawyer, 1956*acd* Baum,

NGC 5272 (cont'd)

1956 van den Bergh, 1956 Haselgrove and Hoyle, 1956 Kourganoff, 1956*cd* Morgan, 1956*ab* Schmidt, 1957 van den Bergh, 1957 Ferrari d'Occhieppo, 1957*I*, *II* von Hoerner, 1957 Kholopov, 1957 Rosino, 1957*I*, *II* Sandage, 1957 Seljach, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*abcdefghijkl* Arp, 1958*abc* Burbidge and Burbidge, 1958 Burbidge and Sandage, 1958 Heckmann, 1958 Kholopov, 1958*I*, *II* Kinman, 1958*c* Ledoux and Walraven, 1958 Maffei (photo), 1958*I*, *II* Sandage, 1958 Saurer, 1958*Idefh*, *II* Sawyer Hogg, 1958 Vandekerkhove, 1958 Wallerstein, 1959 van Agt and Oosterhoff, 1959*abcd* Arp, 1959 Baum, 1959 Dzigvashvili, 1959*Id*, *IIaghij* Kinman, 1959 Kraft, Camp, Hughes, 1959 Kurochkin, 1959 Matsunami *et al.*, 1959*bd* Morgan, 1959 Payne-Gaposchkin, 1959 Preston, 1959 Preston and Spinrad, 1959 Sandage, 1959*Iefghiklmnp*, *IIac*, *III* Sawyer Hogg, 1959 Spinrad, 1959 Struve, 1959 Wallerstein, 1959 Wilson, 1960*abcd* Burbidge, 1960 Eggen, 1960*II*, *III* Hodge, 1960 Johnson, 1960*abcdfgijk* Kron and Mayall, 1960 Kurth, 1960 Pavlovskaya, 1960*bfgh* Roberts, 1960 Sandage and Eggen, 1960 Sandage and Wallerstein, 1960*acef* Wilkens, 1961 van den Bergh, 1961*b* Haffner, 1961 Hénon, 1961 Kurochkin, 1961 Lohmann, 1961 Michie, 1961 Payne-Gaposchkin, 1961 Poveda, 1961 Preston, 1961*I*, *IIb*, *III* Sawyer Hogg, 1961 Stothers and Schwarzschild, 1961 Woolley, 1961*I* Woolley and Dickens, 1962*I*, *IIac* Arp, 1962 van den Bergh and Henry, 1962 Eggen and Sandage, 1962 Fernie, 1962 King, 1962 Kumar, 1962*II* Rosino, 1962*I*, *II* Sandage, 1962 Sawyer Hogg, 1962 Struve.

See also: 5053 1949 Rosino, 6341 1953 Arp, Baum, Sandage, 6205 1954 Baum, 6838 1954 Becker, 6205 1954 Savedoff, 6341 1954 Tayler, 6205 1955 Brown, 7078 1955 Kholopov, 4147 1955 Sandage and Walker, 6838 1956 Artjuchina, Pal 4 1956 van den Bergh, 6121 1956 Kholopov, 3201 1956 Kreiken, 6205 1956 Savedoff, 5024 1957 Cuffey, 7078 1957 Izsak, 5024 1958 Cuffey, 104 1958 Thackeray, 5904 1958 Wallerstein, 6656 1959 Arp and Melbourne, 7078 1959 Bronkalla, 5139 1959 Belserene, 5904 1959 Wallerstein, 5904 1960 Epstein, 104 1960 Feast and Thackeray, 7492 1961 Cuffey, 6121 1961 Idlis, 6838 1961 Stephenson, 104 1961 Wildey, 6205 1962 King, 6356 1962 Wallerstein.

NGC 5286 α 13h 43m.0, δ −51° 07′ l^{II}311°.57, b^{II} + 10°.58

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*I*, *IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959*Iad*, *IIbi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*ad* Wilkens, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 5466 α 14h03m.2, δ + 28° 46′ l^{II}42°.13, b^{II} + 73°.59

1959 Kukarkin, B. V. On five variable stars near globular cluster NGC 5466. *Var. Stars* (Russ.), v. 12, no. 1, pp. 50–52.

1961 Cuffey, J. NGC 5466. *A. J.*, v. 66, 71–82; *Goethe Link Pub.* no. 43, with charts.

1961 Kurochkin, N. E. New variable stars at high galactic latitudes. *Var. Stars* (Russ.), v. 13, no. 5, pp. 331–339.

1928*ab* Ludendorff, 1947*abd* Sawyer, 1948*I* Sawyer, 1949*abcde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1953*d* Rosino, 1954 Cuffey, 1954 Huang, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956 Kreiken, 1956*a* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1958*I*, *II* Kinman, 1959 van Agt and Oosterhoff, 1959*IIa* Kinman, 1959 Matsunami *et al.*, 1959*Icip* (photo) Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960 Sandage and Wallerstein, 1960*acef* Wilkens, 1961*a* Haffner, 1961 Kurochkin, 1961*I*, *IIa*, *III* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

See also: Pal 5 1951 Rosino, 5024 1958 Cuffey, 7492 1961 Cuffey.

NGC 5634 α 14^h 27^m.0, δ − 05° 45′ l^{II}342°.22, b^{II} + 49°.26

1915 Knox Shaw, 1915 Stone, 1921*I* Gregory, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948 Perek, 1948*I* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953*d* Rosino, 1954 Blamont, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*b* Schmidt, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 van Agt and Oosterhoff, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfhik* Kron and Mayall, 1960 Kurth, 1960*acf* Wilkens, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 5694 α 14^{h}36^m.7, δ − 26° 19′ l^{II}331°.06, b^{II} + 30°.37

1915 Stone, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*a* Perek, 1949*acde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*d* Rosino, 1954 Perek, 1954*I* Zagar, 1955 von Hoerner, 1955*I*, *IIbd* Sawyer, 1956*c* Baum, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dzigvashvili, 1959*Id*, *IIi*, *III* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960*acf* Wilkens, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

IC 4499 α 14^h 52^m.7, δ − 82° 02′ l^{II}307°.36, b^{II} − 20°.50

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1949*b* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*c* Baum, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens.

NGC 5824 α 15^h 00^m.9, δ − 32° 53′ l^{II}332°.55, b^{II} + 22°.06

1961 Rosino, L. New variable stars in the globular cluster NGC 5824. *A. S. P. Pub.*, v. 73, pp. 309–313, with plates; *Asiago Cont.*, no. 129.

1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1956*c* Baum, 1956*b* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*II* Sawyer Hogg, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960 Kurth, 1960*ad* Wilkens, 1961*I*, *III* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

Palomar 5 α 15^h 13^m.5, δ + 00° 05′ l^{II}00°.86, b^{II} + 45°.87

1951 Rosino, L. Ricerche sugli ammassi globulari. VI. L'ammasso globulare di Baade in A.R. 15^h 13^m 30^s, E.D. +0° 4′ (1950.0). *Univ. Bologna Oss. Pub.*, v. V, no. 15.

1955 Wilson, A. G. Sculptor-type systems in the local group of galaxies. *A. S. P. Pub.*, v. 67, pp. 27–29. (Discovery).

1956 Pietra, S. Ricerche sugli ammassi globulari. XIII. Periodi e curve di luce di stelle variabili nell'ammasso globulari di Baade in AR 15^h 13^m 30^s; D +0° 4′ (1950.0). *Univ. Bologna Oss. Pub.*, v. VI, no. 16.

1956 Mannino, G. Sul periodo di due stelle variabili nell'ammasso globulare di Baade in AR 15^h 13^m 30^s, D + 0° 4′ (1950.0). *Soc. Astr. Ital. Mem.* (NS), v. 27, pp. 415–416; *Univ. Bologna Oss. Pub.*, v. 6, no. 17.

1962 Kinman, T. D., and Rosino, L. Notes on faint star clusters. *A. S. P. Pub.*, v. 74, pp. 499–506.

1953*ef* Rosino, 1954*I* Zagar, 1955 Abell (No. 5), 1956 van den Bergh, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1959*Iip* Sawyer Hogg, 1960*ad* Wilkens, 1961*I* Sawyer Hogg, 1962 Kinman, 1962*I* Rosino, 1962 Sawyer Hogg.

NGC 5897 α 15^h 14^m.5, δ − 20° 50′ l^{II}342°.94 b^{II} + 30°.29

1915 Knox Shaw, 1947*abd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*d* Rosino, 1953 Sawyer, 1954 Blamont, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958 Burbidge and Sandage, 1958 Heckmann, 1958*I*, *II* Kinman, 1959*IIa* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfhik* Kron and Mayall, 1960 Sandage and Wallerstein, 1960*acf* Wilkens, 1961 Hénon, 1962 Fernie, 1962 Sawyer Hogg.

NGC 5904 (Messier 5) α 15^h 16^m.0, δ + 02° 16′ l^{II}03°.86, b^{II} + 46°.80

1949 Sawyer, H. B. The early discovery of four globular clusters. *R. A. S. C. Jour.*, v. 43, p. 45.

1953 Kholopov, P. N. Space distribution of RR Lyrae variables in the globular clusters M 5 and NGC 3201. *Var. Stars* (Russ.), v. 9, pp. 371–378; *Ast. News Letter*, no. 82, 1956.

1955 Arp, H. C. Cepheids of period greater than one day in globular clusters. *A. J.*, v. 60, pp. 1–17.

1956 Kreiken, E. A. A statistical study of pulsating stars. 3rd paper. The variable stars in Messier 5. *Fac. Sci. Univ. Ankara Comm.*, v. 8, no. 1; *Dept. Astr. Ankara Comm.*, no. 10.

1957 Arp, H. C. Three color photometry of Cepheids W Virginis, M 5 Nos. 42 and 84, and M 10 Nos. 2 and 3. *A. J.*, v. 62, pp. 129–136.

1958 Reddish, V. C. Correlations in the deviations of magnitudes of stars in clusters. *Obs.*, v. 78, pp. 247–249.

1958 Wallerstein, G. Radial velocities and spectral characteristics of the population II Cepheids M 5 no. 42, M 5 no. 84 and TW Capricorni. *Ap. J.*, v. 127, pp. 583–590. (Plates of spectra).

1959 Wallerstein, G. Effective temperatures, radii, masses and pulsation properties of the population II Cepheids M 5 no. 42 and W Virginis. *Ap. J.*, v. 129, pp. 356–361.

1959 Wallerstein, G. The shock-wave model for the population II Cepheids. *Ap. J.*, v. 130, pp. 560–569. (No. 42 in M 5, with print of spectra).

1960 Epstein, E. E. Test for variability of stars near the RR Lyrae gap in M 5. *Ap. J.*, v. 131, pp. 517–518; *Harv. Repr.*, no. 550.

1961 Preston, G. W. Low-dispersion spectra of RR Lyrae stars in globular clusters. *Ap. J.*, v. 134, no. 2, pp. 651–652; *Lick Cont.*, no. 119.

1961 Sandage, A. R. The ages of the open cluster NGC 188 and the globular clusters M 3, M 5, and M 13 compared with the Hubble time. *A. J.*, v. 66, p. 53.

1962 Arp, H. The globular cluster M 5. *Ap. J.*, v. 135, pp. 311–332, with plates.

1962 Sandage, A. The ages of M 67, NGC 188, M 3, M 5, and M 13 according to Hoyle's 1959 models. *Ap. J.*, v. 135, pp. 349–365.

1928*a* Ludendorff, 1935 Walters, 1938*abc* Payne-Gaposchkin and Gaposchkin, 1946 Miczaika, 1947 Parenago, 1947*abcd* Sawyer, 1948 BAAJ, 1948 Becker, 1948 Fehrenbach (error in no.), 1948 Gamalej, 1948*b* Perek, 1948*I*, *II* Sawyer, 1949 Joy, 1949*abcde* Parenago, Kukarkin, Florja, 1949*acdef* Shapley, 1950*cdefg* Becker, 1950 Kurth, 1951*I*, *II* Kurth, 1952 Camm, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1953*di* Rosino, 1953 Shapley and McKibben, 1954 Belserene, 1954 Bidelman, 1954 Blamont, 1954 Gingerich, 1954*a* Payne-Gaposchkin, 1954*b* Rosino,

NGC 5904 (cont'd)

1954*a* Sandage, 1954*I* Zagar, 1955*I*, *II* Arp, 1955 von Hoerner, 1955*II* Reddish, 1955*I*, *IIbcd* Sawyer, 1956*ac* Baum, 1956 van den Bergh, 1956 Kourganoff, 1956*c* Morgan, 1956*ab* Schmidt, 1957 van den Bergh, 1957 Ferrari d'Occhieppo, 1957 Kholopov, 1957 Roman, 1957 Rosino, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*abdej* Arp, 1958 Burbidge and Sandage, 1958 Kholopov, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1958*I* Sandage, 1958*Ieh*, *II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959*abcd* Arp, 1959 Dzigvashvili, 1959 Johnson, 1959*Iabd*, *IIafhij* Kinman, 1959 Kraft, Camp and Hughes, 1959 Kurochkin, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959 Preston, 1959 Sandage, 1959 *Iafikop*, *IIa*, *III* Sawyer Hogg, 1960 *abcdfgijkl* Kron and Mayall, 1960 Kurth, 1960 Pavlovskaya, 1960*bh* Roberts, 1960 Sandage and Wallerstein, 1960*acf* Wilkens, 1960 Wallerstein and Carlson, 1961 van den Bergh, 1961*ab* Haffner, 1961 Hénon, 1961 Lohmann, 1961*I*, *IIb*. *III* Sawyer Hogg, 1961 Payne-Gaposchkin, 1961 Stothers and Schwarzschild, 1962*I*, *IIabcd* Arp, 1962 Bahner, Hiltner and Kraft, 1962 van den Bergh, 1962 Fernie, 1962 Kumar, 1962*II* Rosino, 1962*I*, *II* Sandage, 1962 Sawyer Hogg, 1962 Struve.

See also: 5053 1949 Rosino, 7099 1949 Rosino, 6205 1954 Baum, 5272 1955 Kholopov, 7078 1955 Kholopov, 5272 1955 Roberts and Sandage, 3201 1956 Kreiken, 5272 1956 Kreiken, 104 1957 Gascoigne and Burr, 7078 1957 Izsak, 6656 1959 Arp and Melbourne, 7078 1959 Bronkalla, 5272 1959 Oort and van Kerk, 5272 1961 Smak, 6397 1961 Woolley *et al.*

NGC 5927 $\alpha\ 15^h\ 24^m.4,\ \delta - 50°\ 29'$ $l^{II} 326°.63,\ b^{II} + 04°.86$

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959*Icd*, *IIci* Kinman, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*ad* Wilkens, 1962 Fernie.

NGC 5946 $\alpha\ 15^h\ 31^m.8,\ \delta - 50°\ 30'$ $l^{II} 327°.58,\ b^{II} + 04°.19$

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Idp* Sawyer Hogg, 1960*ad* Wilkens.

NGC 5986 $\alpha\ 15^h\ 42^m.8,\ \delta - 37°\ 37'$ $l^{II} 337°.04,\ b^{II} + 13°.28$

1962 Rosino, L. Ricerche nell'emisfero australe. III. Stelle variabili negli ammassi globulari NGC 5986, 6304, 6558, 6569, 6637 (M 69), 6681 (M 70) e zone attigue. *Soc. Astr. Ital. Mem.*, v. XXXIII, no. 4; *Asiago Cont.*, no. 132.

1935 Walters, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1954 Cimino, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*b* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*II* Sawyer Hogg, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960 Kurth, 1960*ad* Wilkens, 1961 *III* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

Palomar 14 $\alpha\ 16^h\ 08^m.8,\ \delta + 15°\ 05'$ $l^{II} 28°.77,\ b^{II} + 42°.15$

1959 Arp, H. C. The absolute magnitudes, colors, and metal abundances of stars in globular clusters. *A. J.*, v. 64, pp. 441–447. (Page 446, position of new globular cluster discovered by van den Bergh.)

1960 Arp, H., and van den Bergh, S. A new faint globular cluster. *A. S. P. Pub.*, v. 72, p. 48, with print.

1961*b* Haffner.

NGC 6093 (Messier 80) α 16^h 14^m.1, δ − 22° 52′ l^{II}352°.67, b^{II} + 19°.45

1961 Eggen, O. J. Three colour photometry of red variables. *Roy. Obs. Bull.*, no. 29.

1928*b* Ludendorff, 1941 Merrill, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1948*I, II* Sawyer, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1950*eg* Becker, 1951*b* Payne-Gaposchkin, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953*i* Rosino, 1953 Shapley and McKibben, 1954 Bidelman, 1954 Blamont, 1954 Gingerich, 1954*b* Payne-Gaposchkin, 1954*b* Rosino, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956 van den Bergh, 1956 Kreiken, 1956*ab* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1958 Maffei (photo), 1958*II* Sawyer Hogg, 1959 Dzigvashvili, 1959*Id, IIai* Kinman, 1959 Matsunami *et al.*, 1959*Iip, IId* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960*acf* Wilkens, 1961 Hénon, 1961*I, III* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6101 α 16^h 20^m.0, δ − 72° 06′ l^{II}317°.73, b^{II} − 15°.83

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens, 1962 Fernie.

NGC 6121 (Messier 4) α 16^h 20^m.6, δ − 26° 24′ l^{II}350°.99, b^{II} + 15°.97

1949 Sawyer, H. B. The early discovery of four globular clusters. *R. A. S. C. Jour.*, v. 43, p. 45.

1956 Kholopov, P. N. Spatial distribution of stars of various types in the globular cluster M 4. *A. J. UdSSR*, v. 33, p. 46.

1959 Idlis, G. M., and Nikol'skii, G. M. The diffuse medium in globular clusters. *A. J. UdSSR*, v. 36, no. 4, p. 668; *Soviet Astronomy, AJ*, v. 3, no. 4, p. 652, 1960.

1961 Idlis, G. M. A confirmation of the presence of a diffuse medium in globular stellar clusters. *A. J. UdSSR*, v. 38, p. 184; *Soviet Astronomy AJ*, v. 5, no. 1, pp. 135–136.

1963 Hoffmeister, C. Veränderliche Sterne am Südhimmel. *Sonneberg Veröff.*,v. 6, no. 1, p. 7.

1943 Payne-Gaposchkin, Brenton, Gaposchkin, 1946 Miczaika, 1947*abcd* Sawyer, 1948 King, 1948 Maitre, 1948*I* Sawyer, 1949 Gialanella, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1949*dfg* Shapley, 1950*dfg* Becker, 1950 Kurth, 1951*I, II* Kurth, 1952*Iabcd, IIIc* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1953*ij* Rosino, 1953 Shapley and McKibben, 1954 Blamont, 1954 Gingerich, 1954*a* Payne-Gaposchkin, 1954*a* Rosino, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1956*b* Baum, 1956 van den Bergh, 1956*a* Schmidt, 1957 van den Bergh, 1957*II* von Hoerner, 1957 Kholopov, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958*e* Arp, 1958 Heckmann, 1958 Kholopov, 1958*I, II* Kinman, 1958 Maffei (photo), 1958*I* Sandage, 1958*II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959*Iabd, IIad* Kinman, 1959 Kurochkin, 1959 Matsunami *et al.*, 1959 Preston, 1959*Idkip* Sawyer Hogg, 1960 Gingerich, 1960*acfik* Kron and Mayall, 1960*a* Roberts, 1960*acf* Wilkens, 1961 van den Bergh, 1961*b* Haffner, 1961 Hénon, 1961 Payne-Gaposchkin, 1961 *I, III* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

See also: 5272 1953 Sandage, 5272 1955 Kholopov, 7078 1955 Kholopov.

NGC 6139 α 16^h 24^m.3, δ − 38° 44′ l^{II}342°.37, b^{II} + 06°.94

1921*II* Gregory, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959*Iacd, IIci* Kinman, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*ad* Wilkens, 1962 Fernie.

NGC 6144 α 16^h 24^m.2, δ − 25° 56′ l^{II}351°.92, b^{II} + 15°.68

1947*abd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*f* Rosino, 1953 Sawyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958 Maffei (photo), 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960*ad* Wilkens, 1962 Sawyer Hogg.

NGC 6171 (Messier 107) α 16^h 29^m.7, δ − 12° 57′ l^{II}03°.37, b^{II} + 23°.02

1948 Sawyer, H. B. Méchain's additions to Messier's catalogue. *A. J.*, v. 53, p. 117.

1960 Kukarkin, B. V. Preliminary results of investigation of variables in the globular cluster NGC 6171. *Astr. Circ.* (Russ.), no. 216, p. 17.

1961 van Agt, S. L. Th. Pseudo-colour-magnitude diagram of the globular cluster NGC 6171. *B. A. N.*, v. 15, no. 508, pp. 327–329, with plate.

1961 Kukarkin, B. V. A study of variable stars in the globular cluster NGC 6171. *Var. Stars* (Russ.), v. 13, no. 6, pp. 384–389.

1961 Mannino, G. Periodi e curve di luce di 10 stelle variabili dell'ammasso globulare NGC 6171. *Univ. Bologna Oss. Pub.*, v. 7, no. 18.

1947 Parenago, 1947*abcd* Sawyer, 1948 BAAJ, 1948 Becker, 1948 Fehrenbach, 1948*b* Perek. 1948*I* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956*ab* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959*Id, IIi* Kinman, 1959 Matsunami *et al.*, 1959*Idip, III* Sawyer Hogg, 1960*acdefik* Kron and Mayall, 1960 Kurth, 1960*bd* Roberts, 1960*acef* Wilkens, 1961 Hénon, 1961 Lohmann, 1961*I, III* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6205 (Messier 13) α 16^h 39^m.9, δ + 36° 33′ l^{II}59°.00, b^{II} + 40°.91

1922 Lindblad, B. Spectrophotometric methods for determining stellar luminosity. *Ap. J.*, v. 55, pp. 85–118; *Mt. W. Cont.*, no. 228.

1947 Lohmann, W. Die Masse der kugelförmigen Sternhaufen M 3 und M 13. *Z. f. Naturforschung*, v. 2a, p. 477; *Königstuhl-Heidelberg Mitt.*, no. 49.

1950 Vandekerkhove, E. Etude d'amas résultants. *Obs. Roy. Belgique Comm.*, no. 18, pp. 23–26.

1952 Fatchikin, N. V. Determination of the proper motion of the globular cluster M 13. *Pulkova Bull.*, v. 19, pp. 150–154.

1952 Hoag, A. A. Photoelectric photometry of M 13. *A. J.*, v. 57, p. 13.

1954 Baum, W. A. Globular clusters. II. The tentative identification of the main sequence of population II from photoelectric observations in M 13. *A. J.*, v. 59, pp. 422–432.

1954 Savedoff, M. P. Color magnitude array of M 13. *A. J.*, v. 59, p. 192.

1955 Arp, H. C. Cepheids of period greater than one day in globular clusters. *A. J.*, v. 60, pp. 1–17.

1955 Arp, H. C., and Johnson, H. L. The globular cluster M 13. *Ap. J.*, v. 122, pp. 171–176.

1955 Baum, W. A. Counting photons one by one. *Sky and Tel.*, v. 14, p. 334. (Photo and key to sequence for M 13).

1955 Brown, A. Color-magnitude array for stars in the globular cluster M 13. *Ap. J.*, v. 122, pp. 146–170; *McDonald Cont.*, no. 256.

NGC 6205 (cont'd)

1957 Kron, G. E. Star clusters, in and out of the galaxy. *A. S. P. Leaflet*, no. 339, with photo.

1959 Baum, W. A., Hiltner, W. A., Johnson, H. L., and Sandage, A. The main sequence of the globular cluster M 13. *Ap. J.*, v. 130, pp. 749–763 with plate.

1959 Eggen, O. J., and Sandage, A. R. Stellar groups. IV. The Groombridge 1830 group of high velocity stars and its relation to the globular clusters. *M. N.*, v. 119, pp. 255–277.

1959 Hénon, M. L'amas isochrone. II. Calcul des orbites. *Ann. d'Ap.*, v. 22, no. 5, pp. 492–498.

1959 Iriarte, B. Photoelectric photometry of faint blue stars. *Lowell Bull.*, no. 101, v. 4, pp. 130–135.

1959 Roberts, M. S. A search for neutral atomic hydrogen in globular clusters. *Nature*, v. 184, Supp. 20, pp. 1555–1556.

1961 Sandage, A. R. The ages of the open cluster NGC 188 and the globular clusters M 3, M 5, and M 13 compared with the Hubble time. *A. J.*, v. 66, p. 53.

1962 King, I. The distribution of blue stars in M 13. *Ap. J.*, v. 136, pp. 784–787.

1962 Sandage, A. The ages of M 67, NGC 188, M 3, M 5, and M 13 according to Hoyle's 1959 models. *Ap. J.*, v. 135, pp. 349–365.

1789 Wollaston, 1928*a* Ludendorff, 1935 Walters, 1936 Kuiper, 1947 Fricke, 1947 Parenago, 1947*abcd* Sawyer, 1948 BAAJ, 1948 Becker, 1948 Fehrenbach, 1948 Gamalej, 1948 King, 1948 Maitre, 1948*b* Perek, 1948*I, II* Sawyer, 1949 Joy, 1949 *abcde* Parenago, Kukarkin, Florja, 1949*acdeg* Shapley, 1950*a* (photo) *cdef* Becker, 1950 Kurth, 1950 Stebbins, 1951*I, II* Kurth, 1951*b* Payne-Gaposchkin, 1952 Baade, 1952 Camm, 1952*Iabcd, IIab* Lohmann, 1953*a* Deutsch, 1953 Dreyer, 1953 Gingerich (plate), 1953 Kholopov, 1953 Lohmann, 1953*adefhi* Rosino, 1953 Shapley and McKibben, 1954 Blamont, 1954 Cimino, 1954 Gingerich, 1954*b* Payne-Gaposchkin, 1954*b* Rosino, 1954*a* Sandage, 1954*I, II* Zagar, 1955*I, II* Arp, 1955 Baum, 1955 von Hoerner, 1955*I, II* Reddish, 1955*IIbcd* Sawyer, 1955*Ib* Struve, 1956*acd* Baum, 1956 van den Bergh, 1956 Kourganoff, 1956 Kreiken, 1956*c* Morgan, 1956 Roberts, 1956*ab* Schmidt, 1957 Ferrari d'Occhieppo, 1957 Roman, 1957 Rosino, 1957 Seljach, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*abcefghijk* Arp, 1958 Burbidge and Sandage, 1958 Heckmann, 1958*I, II* Kinman, 1958 Maffei (photo), 1958 Náprstková, 1958*I, II* Sandage, 1958 Saurer (photo), 1958*Iei, II* Sawyer Hogg, 1958 Vandekerkhove, 1958 Wallerstein, 1959 van Agt and Oosterhoff, 1959*abcd* Arp, 1959 Baum, 1959 Dzigvashvili, 1959 Johnson, 1959*Id, IIafghij* Kinman, 1959 Kraft, Camp and Hughes, 1959 Matsunami *et al.*, 1959*bd* Morgan, 1959 Sandage, 1959*Iabefhijklp, III* Sawyer Hogg, 1959 Struve, 1959 Wallerstein, 1960*c* Burbidge, 1960 Chalonge, 1960 Eggen, 1960 Johnson, 1960 Kron, 1960*abcdfgijkl* Kron and Mayall, 1960 Kurth, 1960 Markarian, 1960*abcdefh* Roberts, 1960 Sandage and Wallerstein, 1960 Wallerstein and Carlson, 1960*acf* Wilkens, 1961 van den Bergh, 1961*ab* Haffner, 1961 Hénon, 1961 Kurochkin, 1961 Lohmann, 1961*I, IIb, III* Sawyer Hogg, 1961 Slettebak, Bahner and Stock, 1961 Stothers and Schwarzschild, 1962*I, IIabcd* Arp, 1962 van den Bergh and Henry, 1962 Eggen and Sandage, 1962 Fernie, 1962 King, 1962*II* Rosino, 1962*I, II* Sandage, 1962 Sawyer Hogg, 1962 Struve.

See also: 5273 1953 Sandage and Wallerstein, 5272 1954 Sandage, 5272 1956 Baker and Baker, 5272 1957 Johnson, 5904 1958 Wallerstein, 6656 1959 Arp and Melbourne, 5139 1959 Belserene, 6356 1959 Sandage and Wallerstein, 104 1960 Feast and Thackeray, 6121 1961 Idlis, 7078 1961 King, 5272 1961 Smak, 6522 1961 Whitford, 6397 1961 Woolley *et al.*, 6356 1962 Wallerstein.

NGC 6218 (Messier 12) α 16^h 44^m.6, δ − 01° 52′ l^{II}15°.70, b^{II} + 26°.32

1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948*b* Perek, 1948*I* Sawyer, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1949*ace* Shapley, 1950*dg* Becker, 1951*b* Payne-Gaposchkin, 1952 *Iabcd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953*d* Rosino, 1953 Shapley and McKibben, 1954 Bidelman, 1954 Blamont, 1954 Gingerich, 1954*b* Payne-Gaposchkin, 1954 Perek, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 Kreiken, 1956*ab* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dzigvashvili, 1959 Johnson, 1959*Id*, *IIai* Kinman, 1959 Matsunami *et al.*, 1959*Iip*, *III* Sawyer Hogg, 1960*acdfikl* Kron and Mayall, 1960*acf* Wilkens, 1961*b* Haffner, 1961 Hénon, 1961 Lohmann, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6229 α 16^h 45^m.6, δ + 47° 37′ l^{II}73°.64, b^{II} + 40°.30

1960 Mannino, G. Periodi e curve di luce di 12 stelle variabili dell' ammasso globulare NGC 6229. *Soc. Astr. Ital. Mem.*, v. XXXI, nos. 2–3; *Univ. Bologna Oss. Pub.*, v. VII, no. 13.

1961 Mayer, P. Periods of variable stars in globular cluster NGC 6229. *Astr. Inst. Czechoslovakia Bull.*, v. 12, no. 4, pp. 167–168.

1928*a* Ludendorff, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948*b* Perek, 1948*I* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953*d* Rosino, 1953 Sawyer 1954 Blamont, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*c* Morgan, 1956*b* Schmidt, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*II* Sawyer Hogg, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959*Iip* Sawyer Hogg, 1960*acdfik* Kron and Mayall, 1960 Kurth, 1960*acf* Wilkens, 1961*a* Haffner, 1961 Hénon, 1961*I* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 6235 α 16^h 50^m.4, δ − 22° 06′ l^{II}358°.91, b^{II} + 13°.52

1921*I* Gregory, 1944 Wallenquist and Lundby, 1947*d* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952 Johnson, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Sawyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*ad* Wilkens, 1962 Sawyer Hogg.

NGC 6254 (Messier 10) α 16^h 54^m.5, δ − 04° 02′ l^{II}15°.13, b^{II} + 23°.07

1955 Arp, H. C. Cepheids of period greater than one day in globular clusters. *A. J.*, v. 60, pp. 1–17.

1957 Arp, H. C. Three color photometry of Cepheids W Virginis, M 5 Nos. 42 and 84, and M 10 Nos. 2 and 3. *A. J.*, v. 62, pp. 129–136.

1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1948*I* Sawyer, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1950*d* Becker, 1950 Kurth, 1951*I*, *II* Kurth, 1952*Iabd* Lohmann, 1953*b* Deutsch, 1953 Dreyer, 1953 Kholopov, 1953*di* Rosino, 1953 Shapley and McKibben, 1954 Bidelman, 1954 Blamont, 1954 Gingerich, 1954*b* Payne-Gaposchkin, 1954 Perek, 1954*a* Sandage, 1954*I* Zagar, 1955*I*, *II* Arp, 1955 von Hoerner, 1955*II* Reddish, 1955*IIbcd* Sawyer, 1956*ac* Baum, 1956 Kreiken, 1956*ab* Schmidt, 1957 Ferrari d'Occhieppo, 1958 Alter, Ruprecht, Vanýsek, 1958*abej* Arp, 1958 Burbidge and Sandage, 1958*I*, *II* Kinman, 1958*Ie* Sawyer Hogg, 1958 Wallerstein, 1959 Dzigvashvili, 1959 Johnson, 1959*Id*, *IIafij* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959*Ifip*, *III* Sawyer Hogg, 1959 Struve, 1959 Wallerstein, 1960*c* Burbidge, 1960*abcdefgijkl* Kron and Mayall, 1960*bdh* Roberts, 1960 Sandage and Wallerstein, 1960*acf* Wilkens, 1961 van den

NGC 6254 (cont'd)

Bergh, 1961*b* Haffner, 1961 Hénon, 1961 Lohmann, 1961*I* Sawyer Hogg, 1961 Slettebak, Bahner and Stock, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.
See also: 6205 1954 Baum, 5904 1958 Wallerstein, 6656 1959 Arp and Melbourne.

Palomar 15 α 16^h 57^m.6, δ − 00° 28′ l^{II}18°.89, b^{II} + 24°.27

1959 Bowen, I. S. Report of Mount Wilson and Palomar Observatories. *Carnegie Inst. Wash., Year Book* no. 58, p. 60. (Discovery by Zwicky).

1962 Kinman, T. D., and Rosino, L. Notes on faint star clusters. *A. S. P. Pub.*, v. 74, pp. 499–506.

1962*I* Rosino.

NGC 6266 (Messier 62) α 16^h 58^m.1, δ − 30° 03′ l^{II}353°.58, b^{II} + 07°.30

1952 Kholopov, P. N. The ellipticity of globular clusters. *A. J. UdSSR*, v. 29, no. 6, pp. 671–681.

1959 van Agt, S. L. Th., and Oosterhoff, P. Th. Observations of variable stars in the globular clusters NGC 4590 (M 68) and NGC 6266 (M 62). *Leiden Ann.*, v. XXI, 4th pt., pp. 253–290, with plates.

1935 Walters, 1944 Wallenquist and Lundby, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*abde* Parenago, Kukarkin, Florja, 1949*g* Shapley, 1950*cd* Becker, 1951 Thackeray, 1952 Kholopov, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1954 Blamont, 1954 Cimino, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1955*IIb* Struve, 1956 van den Bergh, 1956*b* Morgan, 1956*ab* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*II* Sawyer Hogg, 1959 Dzigvashvili, 1959*Iabd*, *IIbi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acdefik* Kron and Mayall, 1960*acef* Wilkens, 1961 Hénon, 1961*I*, *III* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6273 (Messier 19) α 16^h 59^m.5, δ − 26° 11′ l^{II}356°.88, b^{II} + 09°.40

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1948*I* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1950*cd* Becker, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*g* Rosino, 1954 Blamont, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1955*IIb* Struve, 1956 Kourganoff, 1956*b* Morgan, 1956*ab* Schmidt, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*II* Sawyer Hogg, 1959 Dzigvashvili, 1959 Johnson, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959*Icip*, *III* Sawyer Hogg, 1960*acdfikl* Kron and Mayall, 1960*acf* Wilkens, 1961 Hénon, 1961 Lohmann, 1961*III* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 6284 α 17^h 01^m.5, δ − 24° 41′ l^{II}358°.37, b^{II} + 09°.93

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948 Perek, 1948*I* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954 Blamont, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1955*IIb* Struve, 1956*b* Morgan, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Id*, *IIi*, *III* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acdfik* Kron and Mayall, 1960 Kurth, 1960*acf* Wilkens, 1961 Hénon, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6287 α 17^h 02^m.1, δ − 22° 38′ l^{II}00°.13, b^{II} + 11°.04

1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1948*I* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960*acf* Wilkens, 1962 Sawyer Hogg.

NGC 6293 α 17^h 07^m.1, δ − 26° 30′ l^{II}357°.64, b^{II} + 07°.84

1915 Knox Shaw, 1921*I* Gregory, 1928*a* Ludendorff, 1944 Wallenquist and Lundby, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1948*I* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954 Blamont, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1955*IIb* Struve, 1956*b* Morgan, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dzigvashvili, 1959 Johnson, 1959*Id*, *IIi*, *III* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acdfikl* Kron and Mayall, 1960*acf* Wilkens, 1961 Hénon, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6304 α 17^h 11^m.4, δ − 29° 24′ l^{II}355°.84, b^{II} + 05°.37

1962 Rosino, L. Ricerche astronomiche nell' emisfero australe III. Stelle variabili negli ammassi globulari NGC 5986, 6304, 6558, 6569, 6637 (M 69), 6681 (M 70) e zone attigue. *Soc. Astr. Ital. Mem.*, v. XXXIII, no. 4; *Asiago Cont.*, no. 132.

1921*II* Gregory, 1944 Wallenquist and Lundby, 1947 Parenago, 1947 *abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954 Blamont, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1955*IIb* Struve, 1956*b* Baum, 1956*a* Morgan, 1956*b* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*II* Sawyer Hogg, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959 Johnson, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*c* Morgan, 1959*Igp* Sawyer Hogg, 1960*acdfikl* Kron and Mayall, 1960*ad* Wilkens, 1961*III* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6316 α 17^h 13^m.4, δ − 28° 05′ l^{II}357°.17, b^{II} + 05°.78

1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1955*IIb* Struve, 1956*b* Baum, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dufay and Bigay, 1959 Johnson, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*acfikl* Kron and Mayall, 1960*ad* Wilkens, 1962 Fernie.
See also: HP 1954 Dufay, Berthier, Morignet.

NGC 6325 α 17^h 15^m.0, δ − 23° 42′ l^{II}00°.98, b^{II} + 07°.99

1921*II* Gregory, 1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Ip* Sawyer, 1960*acfik* Kron and Mayall, 1960*ad* Wilkens.

NGC 6333 (Messier 9) α 17^h 16^m.2, δ − 18° 28′ l^{II}05°.53, b^{II} + 10°.72

1948 Sawyer, H. B. Variable stars in the globular cluster Messier 9. *A. J.*, v. 53, p. 203; Summ., *Sky and Tel.*, v. 7, p. 149, 1948; *B. A. A. Jour.*, v. 58, p. 196, 1948; *Pop. A. Tids.*, v. 29, pp. 169–170, 1948.

1951 Sawyer, H. B. Periods of variable stars in the globular cluster Messier 9. *Dunlap Pub.*, v. 1, no. 24.

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948*b* Perek, 1948*I* Sawyer, 1949*abde* Parenago, Kukarkin, Florja,

NGC 6333 (cont'd)

1949*d* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1954 Blamont, 1954 Gingerich, 1954 Perek, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956 van den Bergh, 1956 Kreiken, 1956*b* Morgan, 1956*ab* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 van Agt and Oosterhoff, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acdfik* Kron and Mayall, 1960*acf* Wilkens, 1961 Hénon, 1961 Lohmann, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6341 (Messier 92) α 17^h 15^m.6, δ + 43° 12′ l^{II}68°.35, b^{II} + 34°.86

1947 von der Pahlen, E. Ueber die Entstehung der sphärischen Sternhaufen. *Z. f. Ap.*, v. 24, pp. 68–120; *Astrophys. Obs. Potsdam Mitt.*, no. 18.

1952 Arp, H. C., Baum, W. A., and Sandage, A. R. The H-R diagrams for the globular clusters M 92 and M 3. *A. J.*, v. 57, pp. 4–5.

1953 Arp, H. C., Baum, W. A., Sandage, A. R. The color-magnitude diagram of the globular cluster M 92. *A. J.*, v. 58, pp. 4–10, with plate.

1953 Sandage, A. R. Interpretation of color-magnitude arrays in globular clusters. *Symposium on Astrophysics, University of Michigan.*

1953 Sandage, A. The color magnitude diagram for the globular cluster M 3. *A. J.*, v. 58, pp. 61–75.

1954 Tayler, R. J. The luminosity function for the globular cluster M 92. *A. J.*, v. 59, pp. 413–422.

1954 Undersökningar av de klotformiga stjarnoparna M 3 och M 92. *Pop A. Tids.*, v. 35, pp. 76–78.

1954 Wilson, O. C., and Coffeen, M. The mass of the globular cluster M 92. *Ap. J.*, v. 119, pp. 197–199.

1955 Schwarzschild, M., and Bernstein, S. Note on the mass of M 92. *Ap. J.*, v. 122, pp. 200–202.

1955 Walker, M. F. A search for variable stars of small amplitude in M 3 and M 92. *A. J.*, v. 60, pp. 197–202.

1961 Kurth, R. Kritik der dynamischen Massenschätzung kugelförmiger Sternhaufen. *Z. f. Ap.*, v. 53, pp. 240–246.

1961 Preston, G. W. Low-dispersion spectra of RR Lyrae stars in globular clusters. *Ap. J.*, v. 134, no. 2, pp. 651–652; *Lick Cont.*, no. 119.

1928*a* Ludendorff, 1946 Vogt, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948 Gamalej, 1948 King, 1948*b* Perek, 1948*I* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1950*dfg* Becker, 1950 Stebbins, 1952 Baade, 1952 Camm, 1952*Iabd*, *IIIa* Lohmann, 1953*a* Deutsch, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1953*dj* Rosino, 1954 Becker, 1954 Blamont, 1954 Gingerich, 1954*a* Payne-Gaposchkin, 1954*b* Rosino, 1954*acd* Sandage, 1954 Schwarzschild, 1954*I* Zagar, 1955*II* Arp, 1955 von Hoerner, 1955 Hoyle and Schwarzschild, 1955*I* Reddish, 1955*IIbcd* Sawyer, 1956*acd* Baum, 1956 van den Bergh, 1956 Kourganoff, 1956*c* Morgan, 1956 Roberts, 1956*ab* Schmidt, 1957 van den Bergh, 1957*I*, *II* von Hoerner, 1957 Roman, 1958 Alter, Ruprecht, Vanýsek, 1958*abdefgil* Arp, 1958*ab* Burbidge and Burbidge, 1958 Burbidge and Sandage, 1958*I*, *II* Kinman, 1958 Náprstková, 1958*I*, *II* Sandage, 1958 Saurer, 1958*Ief*, *II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959*ac* Arp, 1959 Baum, 1959 Dzigvashvili, 1959 Johnson, 1959*Id*, *IIafgij* Kinman, 1959 Matsunami *et al.*, 1959*abd* Morgan, 1959*Ifhiklmop*, *III* Sawyer Hogg, 1959 Spinrad, 1960 Bowen, 1960*abc* Burbidge, 1960 Ebert, von Hoerner, Temesváry, 1960 Kron, 1960*abcdfgijkl* Kron and Mayall, 1960 Kurth, 1960 Markarian, 1960*b*

NGC 6341 (cont'd)

Roberts, 1960 Sandage and Eggen, 1960 Sandage and Wallerstein, 1960*acf* Wilkens, 1961 van den Bergh, 1961*ab* Haffner, 1961 Lohmann, 1961 Payne-Gaposchkin, 1961 Poveda, 1961*I, III* Sawyer Hogg, 1961 Slettebak, Bahner and Stock, 1961 Woolley, 1961*I* Woolley and Dickens, 1962*I* Arp, 1962 van den Bergh and Henry, 1962 Eggen and Sandage, 1962 Fernie, 1962 King, 1962*II* Rosino, 1962 Sawyer Hogg.

See also: 5272 1947 Lohmann, 6205 1954 Baum, 6838 1954 Becker, 5272 1954 Sandage, 6205 1954 Savedoff, 6205 1955 Brown, 4147 1955 Sandage and Walker, 5272 1956 Johnson and Sandage, 6205 1956 Savedoff, 104 1957 Gascoigne and Burr, 7078 1957 Izsak, 104 1958 Thackeray, 6356 1959 Sandage and Wallerstein, 104 1960 Feast and Thackeray, 6522 1961 Whitford, 104 1961 Wildey, 6712 1962 Smith and Sandage, 6356 1962 Wallerstein.

NGC 6342 α 17h 18m.2, δ − 19° 32′ l^{II}04°.90, b^{II} + 09°.73

1921*II* Gregory, 1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960 *acfik* Kron and Mayall, 1960*ad* Wilkens.

NGC 6352 α 17h 21m.6, δ − 48° 26′ l^{II}341°.37, b^{II} − 07°.19

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens, 1962 Fernie.

NGC 6355 α 17h 20m.9, δ − 26° 19′ l^{II}359°.58, b^{II} + 05°.42

1915 Knox Shaw, 1921*I* Gregory, 1947*abd* Sawyer, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*b* Baum, 1958 Alter, Ruprecht, Vanýsek, 1959*Ip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960*ad* Wilkens.

NGC 6356 α 17h 20m.7, δ − 17° 46′ l^{II}06°.73, b^{II} + 10°.21

1959 Sandage, A., and Wallerstein, G. The color-magnitude diagram of the nuclear globular cluster NGC 6356 compared with halo clusters. *A. J.*, v. 64, p. 345.

1960 Sandage, A., and Wallerstein, G. Color-magnitude diagram for the disk globular cluster NGC 6356 compared with halo clusters. *Ap. J.*, v. 131, pp. 598–609, with plates.

1962 Wallerstein, G. Stellar content of the galaxy's nuclear bulge. *A. J.*, v. 67, no. 6, pp. 329–333; *Berkeley Repr.* no. 207.

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948*b* Perek, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Sawyer, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*acd* Morgan, 1956*ab* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958 Burbidge and Sandage, 1958 Heckmann, 1958*I, II* Kinman, 1958*Ifg* Sawyer Hogg, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Id, IIhi, III* Kinman, 1959*a* Larsson-Leander, 1959 Matsunami *et al.*, 1959*abc* Morgan, 1959 Preston, 1959*Ic* (photo) *gip, III* Sawyer Hogg, 1959*b* Thackeray, 1960 Bowen, 1960*I* Hodge, 1960*acdfikn* Kron and Mayall, 1960 Sandage and Eggen, 1960*acf* Wilkens, 1961 van den Bergh, 1961*a* Haffner, 1961 Hénon, 1961 Preston, 1961*I, IIab* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

See also: 104 1961 Wildey, 6712 1962 Smith and Sandage.

Haute Provence 1 $\alpha\ 17^h\ 24^m.9,\ \delta - 29°\ 57'$ $l^{II}357°.06,\ b^{II} + 02°.65$

1954 Dufay, J., Berthier, P., and Morignet, B. Un nouvel amas globulaire dans la région du centre de la Voie Lactée. *C. R. Acad. Sci. Fr.*, v. 239, pp. 478–480; *Haute-Provence Pub.*, v. 3, no. 17.
1956 Bakos, G. A. A new globular cluster near the galactic centre. *R. A. S. C. Jour.*, v. 50, p. 224.
1957 Ursa Ny Kuglehob. *Urania, København*, v. 14, p. 8.

1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1959 Dufay and Bigay, 1959*Ip* Sawyer Hogg.

NGC 6362 $\alpha\ 17^h\ 26^m.6,\ \delta - 67°\ 01'$ $l^{II}325°.54,\ b^{II} - 17°.56$

1961 van Agt, S. L. Th. New variable stars in the southern globular cluster NGC 6362. *B. A. N.*, v. 15, no. 508, pp. 329–330.
1961 Van Hoof, A. Elements for fifteen variables in the globular cluster NGC 6362. *Lab. d'Astr. et Géod. Univ. Louvain Pub.*, no. 126, pp. 1–5.

1928*a* Ludendorff, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1951 Thackeray, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956 van den Bergh, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959*Iad, IIa* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*bcg* Wilkens, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Rosino and Sawyer Hogg, 1962 Sawyer Hogg.

NGC 6366 $\alpha\ 17^h\ 25^m.1,\ \delta - 05°\ 02'$ $l^{II}18°.42,\ b^{II} + 16°.03$

1959 Dufay, J. Sur la région centrale de la galaxie. *C. R., Acad Sci. Fr.*, v. 248, p. 647; *Haute-Provence Pub.*, v. 4, no. 35.
1960 Dufay, J. La condensation centrale de la galaxie. *Ann. d'Ap.*, v. 23, pp. 451–464; *Haute-Provence Pub.*, v. 5, no. 5.

1921*I* Gregory, 1947*abd* Sawyer, 1948*I* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Iip, III* Sawyer Hogg, 1960*acf* Wilkens, 1962 Sawyer Hogg.

NGC 6380 $\alpha\ 17^h\ 31^m.9,\ \delta - 39°\ 02'$ $l^{II}350°.28,\ b^{II} - 03°.56$

1847 Herschel, J. F. W. Results of astronomical observations at the Cape of Good Hope. 4°. Chap. 1. Of the nebulae of the southern hemisphere. (JH 3688; drawing, Plate VI, fig. 18.)
1864 Herschel, J. F. W., 1888 Dreyer, J. L. E. See Section B, *Dunlap Pub.*, v. 1, no. 20.
1954 Thackeray, A. D. *Private communication.* Definite classification as globular cluster.
1959 Pismis, P. New southern star clusters. *Tonantzintla and Tacubaya Bull.*, no. 18, pp. 37–38.
1962 Pismis, P. *Private communication.* No. 1 (above) identified as NGC 6380.

1912 Knox Shaw, 1953 Dreyer, 1955*IIa* Sawyer, 1958 Heckmann, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens.

NGC 6388 α 17^h 32^m.6, δ − 44° 43′ l^{II}345°.54, b^{II} − 06°.74

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959*Iad, IIbi* Kinman, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens, 1962 Fernie.

Tonantzintla 2 α 17^h 32^m.7, δ − 38° 32′ l^{II}350°.79, b^{II} − 03°.42

1959 Pismis, P. New southern star clusters. *Tonantzintla and Tacubaya Bull.*, no. 18, pp. 37–38.

1962 Perek, L. *Private communication.* Correction +20′ to declination first published.

NGC 6397 α 17^h 36^m.8, δ − 53° 39′ l^{II}338°.18, b^{II} − 11°.98

1952 Swope, H., and Greenbaum, I. A study of the magnitudes and colors of the globular cluster NGC 6397. *A. J.*, v. 57, pp. 83–91.

1960 Eggen, O. J. The two-colour relation for horizontal branch stars in globular clusters. *M. N. A. S. S. A.*, v. 19, no. 9, pp. 115–117.

1961 Woolley, R. v.d. R., Alexander, J. B., Mather, L., and Epps, E. Photographic photometry of the globular cluster NGC 6397. *Roy. Obs. Bull.*, no. 43.

1961 Woolley, R. v.d. R. Globular clusters. *Obs.*, v. 81, no. 924, pp. 161–182.

1928*b* Ludendorff, 1947*abd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*a* Shapley, 1951*d* Payne-Gaposchkin, 1952 Baade, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953*j* Rosino, 1954*a* Payne-Gaposchkin, 1954*a* Rosino, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1956*b* Baum, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1958*I, II* Kinman, 1958*II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959*Iad, IIabdi* Kinman, 1959 Matsunami *et al.*, 1959*Ifip* Sawyer, 1960*bcg* Wilkens, 1961*a* Haffner, 1961*I* Sawyer Hogg, 1962*IIe* Arp, 1962*I* Sandage, 1962 Sawyer Hogg. *See also*: 5272 1953 Sandage, 6205 1962 King.

NGC 6401 α 17^h 35^m.6, δ − 23° 53′ l^{II}03°.45, b^{II} + 03°.97

1912 Knox Shaw, 1947*abd* Sawyer, 1948*I* Sawyer, 1953 Dreyer, 1954*I* Zagar, 1955 *IIa* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959*Ip* Sawyer Hogg, 1960*acefhikm* Kron and Mayall, 1960*ad* Wilkens,

NGC 6402 (Messier 14) α 17^h 35^m.0, δ − 03° 15′ l^{II}21°.30, b^{II} + 14°.78

1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948 Fehrenbach, 1948*b* Perek, 1948*I* Sawyer, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1949*d* Shapley, 1950 Kurth, 1951*II* Kurth, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953 Shapley and McKibben, 1954 Bidelman, 1954 Gingerich, 1954 Perek, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956 van den Bergh, 1956*ab* Schmidt, 1957 van den Bergh, 1957 Kholopov, 1958 Alter, Ruprecht, Vanýsek, 1958 Kholopov, 1958*I, II* Kinman, 1958*II* Sawyer Hogg, 1959 Dzigvashvili, 1959 Johnson, 1959*Id, IIi* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959*Iip* Sawyer Hogg, 1960*abcfikl* Kron and Mayall, 1960*bd* Roberts, 1960*acf* Wilkens, 1961 Hénon, 1961 Lohmann, 1961*I, III* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

Palomar 6 α 17^h 40^m.6, δ − 26° 12′ l^{II}02°.09, b^{II} + 01°.78

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society-Palomar Observatory sky survey. *A. S. P. Pub.*, v. 67, pp. 258–261. (Discovery by Abell).

1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1959*Ip* Sawyer Hogg.

NGC 6426 α 17h 42m.4, δ + 03° 12′ l^{II}28°.07, b^{II} + 16°.28

1958 Grubissich, C. L'ammasso globulare NGC 6426 e i suoi dintorni. *Asiago Cont.*, no. 94.

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*II* Sawyer Hogg, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfhik* Kron and Mayall, 1960*acf* Wilkens, 1961*I*, *III* Sawyer Hogg, 1962 Sawyer Hogg.

NGC 6440 α 17h 45m.9, δ − 20° 21′ l^{II}07°.72, b^{II} + 03°.80

1915 Stone, 1921*II* Gregory, 1944 Wallenquist and Lundby, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1950 Stebbins, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1956*ac* Morgan, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958 Burbidge and Sandage, 1958*I*, *II* Kinman, 1958*If* Sawyer Hogg, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*bc* Morgan, 1959*Igp* Sawyer Hogg, 1960 Kron, 1960*acdefik* Kron and Mayall, 1960 Kurth, 1960*ad* Wilkens, 1962 Fernie, 1962*II* Rosino.

NGC 6441 α 17h 46m.8, δ − 37° 02′ l^{II}353°.53, b^{II} − 05°.00

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1956*a* Morgan, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*c* Morgan, 1959*Igp* Sawyer Hogg, 1960*d* Kron and Mayall, 1960*bd* Wilkens, 1962 Fernie.

NGC 6453 α 17h 48m.0, δ − 34° 37′ l^{II}355°.74, b^{II} − 03°.97

1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*b* Baum, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*acefhikm* Kron and Mayall, 1960*bd* Wilkens.

NGC 6496 α 17h 55m.5, δ − 44° 15′ l^{II}348°.08, b^{II} − 10°.01

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens.

NGC 6517 α 17h 59m.1, δ − 08° 57′ l^{II}19°.23, b^{II} + 06°.77

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1950*b* Becker, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959 Dufay and Bigay, 1959 Johnson, 1959 Matsunami *et al.*, 1959*Idp*, *III* Sawyer Hogg, 1960*acfikl* Kron and Mayall, 1960*ad* Wilkens.

NGC 6522 α 18h 00m.4, δ − 30° 02′ l^{II}01°.03, b^{II} − 03°.93

1949 Gaposchkin, S. New variables in NGC 6522. *A. J.*, v. 54, no. 7, p. 185.

1951 Baade, W. Galaxies—present day problems. *Univ. Mich. Obs. Pub.*, v. X, pp. 7–17. (Four cluster type variables in 6522).

1954 Nassau, J. J., Blanco, V. M., McCuskey, S. W. M stars in the vicinity of NGC 6522. *A. J.*, v. 59, p. 334 (title only).

1955 Gaposchkin, S. 285 variable stars in the region of the galactic nucleus. *Ast. Circ.* (Russ.), v. 10, pp. 337–381, with print.

NGC 6522 (cont'd)

1958 Nassau, J. J., and Blanco, V. M. M-type stars and red variables in the galactic center. (Plates.) *Ap. J.*, v. 128, pp. 46–56; Summ., *A. J.*, v. 63, p. 383.
1959 Dufay, J. Sur la région centrale de la galaxie. *C. R., Acad. Sci. Fr.*, v. 248, p. 647; *Haute-Provence Pub.*, v. 4, no. 35.
1960 Dufay, J. La condensation centrale de la galaxie. *Ann. d'Ap.*, v. 23, pp. 451–464; *Haute-Provence Pub.*, v. V, no. 5.
1960 Pavlovskaya, E. D. The periods of short-period Cepheids in the direction to the galactic nucleus. *Var. Stars* (Russ.), v. 13, no. 1, pp. 8–25.
1961 Pavlovskaya, E. D. RR Lyrae variables in the direction of the galactic centre. *Obs.*, v. 81, no. 922, p. 107.
1961 Weaver, H. The scale of the galaxy: a symposium. I. Introduction. *A. S. P. Pub.*, v. 73, pp. 88–94.
1961 Whitford, A. E. The distance to the galactic center from the photometry of objects in the nuclear region. *A. S. P. Pub.*, v. 73, pp. 94–98.

1921*I* Gregory, 1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabcd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1956*b* Baum, 1956*bc* Morgan, 1958 Alter, Ruprecht, Vanýsek, 1958 Burbidge and Sandage, 1958*I*, *II* Kinman, 1959 van Agt and Oosterhoff, 1959 Dufay and Bigay, 1959 Johnson, 1959 Kron and Mayall, 1959*a* Larsson-Leander, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959 Preston, 1959*Iip* Sawyer Hogg, 1960*acefiklmn* Kron and Mayall, 1960 Morgan, 1960*bcg* Wilkens, 1961*a* Haffner, 1961 *I*, *III* Sawyer Hogg, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.
See also: 6656 1959 Arp.

NGC 6528 α 18^h 01^m.6, δ − 30° 04′ l^{II}01°.13, b^{II} − 04°.17

1955 Gaposchkin, S. 285 variable stars in the region of the galactic nucleus. *Ast. Circ.* (Russ.), v. 10, pp. 337–381, with print.

1921*I* Gregory, 1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*I*, *IIbd* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959 Dufay and Bigay, 1959 Matsunami *et al.*, 1959*abc* Morgan, 1959*Iip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960 Morgan, 1960*bcg* Wilkens, 1961*b* Haffner, 1961*I*, *IIb*, *III* Sawyer Hogg, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 6535 α 18^h 01^m.3, δ − 00° 18′ l^{II}27°.18, b^{II} + 10°.43

1921*I* Gregory, 1947*d* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1952 Johnson, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Sawyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959 Dufay and Bigay, 1959 Johnson, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*ad* Wilkens, 1962 Sawyer Hogg.

NGC 6539 α 18^h 02^m.1, δ − 07° 35′ l^{II}20°.80, b^{II} + 06°.78

1921*I* Gregory, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabcd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960*ad* Wilkens, 1962 Sawyer Hogg.

NGC 6541 α 18^h 04^m.4, δ − 43° 44′ l^{II}349°.28, b^{II} − 11°.19

1928*ab* Ludendorff, 1947*abd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953*f* Rosino, 1954*I* Zagar, 1955*IIbcd* Sawyer,

NGC 6541 (cont'd)

1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*II* Sawyer Hogg, 1959*Iad*, *IIbei* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*bcg* Wilkens, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6544 α 18^h 04^m.3, δ − 25° 01′ l^{II}05°.83, b^{II} − 02°.22

1953 Svolopoulos, S. N. A photographic survey of galactic clusters. NGC 6531, 6646, 6469, 6544, 7127, 7128. *M. N.*, v. 113, pp. 758–768.

1921*I* Gregory, 1947 Parenago, 1947*abd* Sawyer, 1948*a* Perek, 1953 Dreyer, 1954 Perek, 1954*I* Zagar, 1955*IIa* Sawyer (omitted in error), 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958 Maffei (photo), 1958*II* Sawyer Hogg, 1959*Id*, *IIi* Kinman, 1959*Ip* Sawyer Hogg, 1960*acfhik* Kron and Mayall, 1960*bd* Wilkens.

NGC 6553 α 18^h 06^m.3, δ − 25° 56′ l^{II}05°.25, b^{II} − 03°.06

1949 Mayall, M. W. Six novae, one with a late-type spectrum. *A. J.*, v. 54, p. 191 (misprint in cluster number).

1956 Thackeray, A. D. *Private communication.* Shapley's variables 1 and 2 doubtful.

1921*I* Gregory, 1928*a* Ludendorff, 1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1950 Stebbins, 1951 Thackeray, 1952*Iabcd*, *IIIc* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1956*a* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1959 van Agt and Oosterhoff, 1959 Dufay and Bigay, 1959 Johnson, 1959 Matsunami *et al.*, 1959*abcd* Morgan, 1959*Idip*, *IId* Sawyer Hogg, 1959*b* Thackeray, 1960 Kron, 1960*acefikl* Kron and Mayall, 1960 Morgan, 1960*bcg* Wilkens, 1961*b* Haffner, 1961*I*, *IIb* Sawyer Hogg, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 6558 α 18^h 07^m.0, δ − 31° 47′ l^{II}00°.19, b^{II} − 06°.02

1847 Herschel, J. F. W. Results of astronomical observations at the Cape of Good Hope. 4°. (Discovery).

1864 Herschel, J. F. W., 1888 Dreyer, J. L. E. See Section B, *Dunlap Pub.*, v. 1, no. 20.

1954 Rosino, L. XI. Su alcuni ammassi stellari di dubbia classificazione. *Asiago Cont.*, no. 52, *La Ricerca Scientifica*, Aug. 1954 (photo).

1954 Thackeray, A. D. *Private communication.* Radcliffe photos confirm globular cluster classification by Gregory in *Helwan Bull.*, nos. 21, 22, 1921.

1962 Rosino, L. Ricerche astronomiche nell' emisfero australe. III. Stelle variabili negli ammassi globulari NGC 5986, 6304, 6558, 6569, 6637 (M 69), 6681 (M 70) e zone attigue. *Soc. Astr. Ital. Mem.*, v. 33, no. 4; *Asiago Cont.*, no. 132, pp. 1–12, with plates.

1921*I*, *II* Gregory, 1953 Dreyer, 1955*IIa* Sawyer, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958 Maffei (photo), 1958*II* Sawyer Hogg, 1959*Iip* Sawyer Hogg, 1960*bcg* Wilkens, 1961*III* Sawyer Hogg, 1962 Sawyer Hogg.

IC 1276 α 18^h 08^m.0, δ − 07° 14′ l^{II}21°.82, b^{II} + 05°.67

1889 Swift, L. Catalogue No. 8 of nebulae discovered at the Warner Observatory. *A. N.*, v. 122, no. 2918, pp. 240–246. (Discovery, no. 95).

1895 Dreyer, J. L. E. Index catalogue of nebulae found in the years 1888–1894. *Roy. Astr. Soc. Mem.*, v. 51.

IC 1276 (cont'd)

1948 Baade, W. *Private correspondence.* Considered globular by Baade and N. U. Mayall.

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory sky survey. *A. S. P. Pub.*, v. 67, pp. 258–261. (No. 7 in Abell's catalogue).

1962 Kinman, T. D., and Rosino, L. Notes on faint star clusters. *A. S. P. Pub.*, v. 74, pp. 499–506, with print.

1953 Dreyer, 1955*IIa* Sawyer, 1958*Ia* Sawyer Hogg, 1959*Ip, IIb* Sawyer Hogg (photo), 1960*ad* Wilkens, 1962 Rosino, 1962*I* Rosino and Sawyer Hogg, 1962 Sawyer Hogg.

NGC 6569 α 18^h 10^m.4, δ − 31° 50′ l^{II}00°.49, b^{II} − 06°.68

1962 Rosino, L. Ricerche astronomiche nell' emisfero australe. III. Stelle variabili negli ammassi globulari NGC 5986, 6304, 6558, 6569, 6637 (M 69), 6681 (M 70) e zone attigue. *Soc. Astr. Ital. Mem.*, v. 33, no. 4; *Asiago Cont.*, no. 132, pp. 1–12, with plates.

1921*I, II* Gregory, 1944 Wallenquist and Lundby, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*IIa* Sawyer, 1956*a* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958*II* Sawyer Hogg, 1959 Johnson, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*acfikl* Kron and Mayall, 1960*bd* Wilkens, 1961*III* Sawyer Hogg.

NGC 6584 α 18^h 14^m.6, δ − 52° 14′ l^{II}342°.14, b^{II} − 16°.41

1928*b* Ludendorff, 1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955*I, IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1959*Icd, IIci* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*bcg* Wilkens, 1961*I* Sawyer Hogg, 1962 Sawyer Hogg.

NGC 6624 α 18^h 20^m.5, δ − 30° 23′ l^{II}02°.80, b^{II} − 07°.92

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1956*a* Morgan, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959 Johnson, 1959*Id, IIi* Kinman, 1959 Matsunami *et al.*, 1959*c* Morgan, 1959*Igp* Sawyer Hogg, 1960*acdfikl* Kron and Mayall, 1960*bd* Wilkens, 1962 Fernie.

NGC 6626 (Messier 28) α 18^h 21^m.5, δ − 24° 54′ l^{II}07°.80, b^{II} − 05°.59

1949 Sawyer, H. B. The variable stars in the globular cluster Messier 28. *A. J.*, v. 54, p. 193.

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1949*a* Shapley, 1950*d* Becker, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*b* Morgan, 1956*ab* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1959 Dzigvashvili, 1959 Johnson, 1959*Id, IIi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acdfikl* Kron and Mayall, 1960*bcg* Wilkens, 1961 Hénon, 1961*I* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6637 (Messier 69) α 18^h 28$^m\!.$1, δ − 32° 23′ l^{II}01°.72, b^{II} − 10°.26

1962 Rosino, L. Ricerche astronomiche nell' emisfero australe. III. Stelle variabili negli ammassi globulari NGC 5986, 6304, 6558, 6569, 6637 (M 69), 6681 (M 70) e zone attigue. *Soc. Astr. Ital. Mem.*, v. 33, no. 4; *Asiago Cont.*, no. 132, pp. 1–12, with plates.

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1956*ac* Morgan, 1956*ab* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958 Burbidge and Sandage, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1958*If* Sawyer Hogg, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*bc* Morgan, 1959*Igp* Sawyer Hogg, 1960 Gingerich, 1960*acdfik* Kron and Mayall, 1960*bd* Wilkens, 1961*a* Haffner, 1961*III* Sawyer Hogg, 1962 Fernie, 1962*II* Rosino.

NGC 6638 α 18^h 27$^m\!.$9, δ − 25° 32′ l^{II}07°.90, b^{II} − 07°.16

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker 1948*b* Perek, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*c* Rosino, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1956*a* Morgan, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959 Johnson, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*c* Morgan, 1959*Igp* Sawyer Hogg, 1960*acdfhikl* Kron and Mayall, 1960 Kurth, 1960*bd* Wilkens, 1961 Hénon, 1962 Fernie.

NGC 6642 α 18^h 28$^m\!.$4, δ − 23° 30′ l^{II}09°.78, b^{II} − 06°.34

1789 Herschel, W. Catalogue of a second thousand of new nebulae and clusters of stars. *Roy. Soc. Phil. Trans.*, v. 79, pp. 212–255. (Discovery).

1833 Herschel, J. F. W., 1847 Herschel, J. F. W., 1864 Herschel, J. F. W. See Section B, *Dunlap Pub.*, v. 1, no. 20.

1948 Baade, W. *Private communication.* Identified as globular.

1953 Dreyer, 1955*IIa* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1959*b* Morgan, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens.

NGC 6652 α 18^h 32$^m\!.$5, δ − 33° 02′ l^{II}01°.53, b^{II} − 11°.38

1944 Wallenquist and Lundby, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1956*a* Morgan, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*c* Morgan, 1959*Igp* Sawyer Hogg, 1960*acdefik* Kron and Mayall, 1960 Kurth, 1960*bd* Wilkens, 1962 Fernie.

NGC 6656 (Messier 22) α 18^h 33$^m\!.$3, δ − 23° 58′ l^{II}09°.87, b^{II} − 07°.55

1959 Arp, H. C. Stars in the direction of the galactic center. *A. J.*, v. 64, pp. 33–34.

1959 Arp, H. C., and Melbourne, W. G. Color-magnitude diagram for the globular cluster M 22. *A. J.*, v. 64, pp. 28–32, with plate.

1928*a* Ludendorff, 1936 Kuiper, 1947 Parenago, 1947*abcd* Sawyer, 1948 BAAJ, 1948 Becker, 1948 Joy, 1948*b* Perek, 1948*I* Sawyer, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1949*g* Shapley, 1950*cde* Becker, 1950 Kurth, 1951*I*, *II* Kurth, 1951*b* Payne-Gaposchkin, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1953*gh* Rosino, 1953 Shapley and McKibben, 1954 Bidelman, 1954 Blamont, 1954 Gingerich, 1954*Iab* Payne-Gaposchkin, 1954*I* Zagar, 1955 von

NGC 6656 (cont'd)

Hoerner, 1955*IIbcd* Sawyer, 1955*IIa* Struve, 1956*b* Baum, 1956 van den Bergh, 1956 Kourganoff, 1956 Kreiken, 1956*ab* Schmidt, 1957 van den Bergh, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*abe* Arp, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1958*I* Sandage, 1958*II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959 Dzigvashvili, 1959 Johnson, 1959*Iabd*, *IIai* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959 Preston, 1959*Iakp*, *III* Sawyer Hogg, 1960 Gingerich, 1960*acfgijkl* Kron and Mayall, 1960 Kurth, 1960*h* Roberts, 1960 Sandage and Wallerstein, 1960*bcg* Wilkens, 1961 van den Bergh, 1961 Hénon, 1961*a* Haffner, 1961 Lohmann, 1961 Payne-Gaposchkin, 1961*I* Sawyer Hogg, 1961*I* Woolley and Dickens, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.
See also: 5053 1949 Rosino.

Palomar 8 α 18ʰ 38ᵐ.5, δ − 19° 52′ l^{II}14°.11, b^{II} −06 °.79

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory sky survey. *A. S. P. Pub.*, v. 67, pp. 258–261. (Discovery by Abell).

1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1959*Ip* Sawyer Hogg.

NGC 6681 (Messier 70) α 18ʰ 40ᵐ.0, δ − 32° 21′ l^{II}02°.85, b^{II} − 12°.52

1962 Rosino, L. Ricerche astronomiche nell' emisfero australe. III. Stelle variabili negli ammassi globulari NGC 5986, 6304, 6558, 6569, 6637 (M 69), 6681 (M 70) e zone attigue. *Soc. Astr. Ital. Mem.*, v. 33, no. 4; *Asiago Cont.*, no. 132, pp. 1–12, with plates.

1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd*, *II* Lohmann, 1953 Dreyer, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIa* Sawyer, 1956*b* Schmidt, 1958*I*, *II* Kinman, 1958 Alter, Ruprecht, Vanýsek, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*Ip* Sawyer Hogg, 1960*acdefik* Kron and Mayall, 1960 Kurth, 1960*bd* Wilkens, 1961*III* Sawyer Hogg, 1962 Fernie.

NGC 6712 α 18ʰ 50ᵐ.3, δ − 08° 47′ l^{II}25°.34, b^{II} − 04°.32

1924 Cannon, A. J. Fifty-nine new variable stars. *Harv. Circ.*, no. 265.
1928 Harwood, M. A survey of the variable stars in the Scutum Cloud; preliminary results. *Harv. Bull.*, no. 880, pp. 10–16.
1962 Harwood, M. The variable stars in the Scutum Cloud. *Leiden Ann.*, v. 21, pt. 8, pp. 387–464.
1962 Smith, L., and Sandage, A. The color-magnitude diagram of the strong-line globular cluster NGC 6712. *A. J.*, v. 67, p. 121.

1928*a* Ludendorff, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1948*I* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Sawyer, 1954 Blamont, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*a* Morgan, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1958*II* Sawyer Hogg, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Id*, *IIi*, *III* Kinman, 1959*a* Larsson-Leander, 1959 Matsunami *et al.*, 1959*bc* Morgan, 1959 Preston, 1959*Igip* Sawyer Hogg, 1960*acdfik* Kron and Mayall, 1960*bcg* Wilkens, 1961 Lohmann, 1961*I*, *III* Sawyer Hogg, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 6715 (Messier 54) α 18h 52m.0, δ − 30° 32′ l^{II}05°.63, b^{II} − 14°.11

1952 Rosino, L. Ricerche sugli ammassi globulari VII. Ventotto nuove variabili nell'ammasso globulare M 54 = NGC 6715. *Univ. Bologna Oss. Pub.*, v. V, no. 18.

1959 Rosino, L., and Nobili, F. Ricerche astronomiche nell' emisfero australe 1. Scoperta e studio preliminare di ettantadue stelle variabili nell'ammasso globulare Messier 54 = NGC 6715. *Asiago Cont.*, no. 97, with plates.

1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*f* Rosino, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*ab* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1958*II* Sawyer Hogg, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Iabd*, *IIbi* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959*Iip*, *IIa* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960*bcg* Wilkens, 1961 Hénon, 1961*I*, *III* Sawyer Hogg, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 6717 α 18h 52m.1, δ − 22° 47′ l^{II}12°.86, b^{II} − 10°.91

1802 Herschel, W. Catalogue of 500 new nebulae and clusters, with remarks on the construction of the heavens. *Roy. Soc. Phil. Trans.*, v. 92, pp. 477–528. (Discovery by Herschel).

1833 Herschel, J. F. W., 1847 Herschel, J. F. W., 1864 Herschel, J. F. W., 1888 Dreyer, J. L. E. See Section B, *Dunlap Pub.*, v. 1, no. 20.

1948 Baade, W. *Private correspondence.* Considered globular cluster by Baade and N. U. Mayall.

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory sky survey. *A. S. P. Pub.*, v. 74, pp. 499–506. (No. 9 in catalogue).

1953 Dreyer, 1955*IIa* Sawyer, 1958 Alter, Ruprecht, Vanýsek, 1958*II* Sawyer Hogg, 1959*Ip* Sawyer Hogg, 1960*bd* Wilkens, 1961*III* Sawyer Hogg.

NGC 6723 α 18h 56m.2, δ − 36° 42′ l^{II}00°.07, b^{II} − 17°.30

1912 Knox Shaw, 1928*a* Ludendorff, 1938*b* Payne-Gaposchkin and Gaposchkin, 1946 Miczaika, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*abde* Parenago, Kukarkin, Florja, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956 van den Bergh, 1956*ab* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*I* Sandage, 1959 van Agt and Oosterhoff, 1959 Dzigvashvili, 1959*Id*, *IIi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acdefik* Kron and Mayall, 1960*bcg* Wilkens, 1961 Hénon, 1961 Lohmann, 1961 Payne-Gaposchkin, 1961*I* Sawyer Hogg, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6752 α 19h 06m.4, δ − 60° 04′ l^{II}336°.49, b^{II} − 25°.62

1947*abd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ace* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*d* Rosino, 1954*I* Zagar, 1955 *IIbd* Sawyer, 1956*c* Baum, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958*II* Sawyer Hogg, 1959*Iad*, *IIabi* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1959*a* Thackeray, 1960*bcg* Wilkens, 1962 Aller, 1962 Fernie, 1962 Sawyer Hogg.

See also: 5139 1962 Fehrenbach and Duflot.

NGC 6760 α 19^h 08^m.6, δ + 00° 57′ l^{II}36°.10, b^{II} − 03°.91

1947*abd* Sawyer, 1949*ade* Parenago, Kukarkin, Florja, 1950 Stebbins, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953 Sawyer, 1954 Blamont, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1959 Dufay and Bigay, 1959 Matsunami *et al.*, 1959*bc* Morgan, 1959*Iip* Sawyer Hogg, 1960 Kron, 1960*acfik* Kron and Mayall, 1960*bd* Wilkens, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 6779 (Messier 56) α 19^h 14^m.6, δ + 30° 05′ l^{II}62°.65, b^{II} + 08°.34

1949 Sawyer, H. B. Two RV Tauri-type variables in globular clusters. *R. A. S. C. Jour.*, v. 43, pp. 38–44; *Dunlap Comm.*, no. 18.

1950 Rosino, L. Ricerche sugli ammassi globulari III. Su alcune interessanti stelle variabili appartenenti o vicine all'ammasso globulare M 56 della Lira. *Univ. Bologna Oss. Pub.*, v. V, no. 12; *Soc. Astr. Ital. Mem.*, v. XXI, no. 1.

1951 Rosino, L. Diagramma colore-grandezza e distanza dell'ammasso globulare M 56. *Asiago Cont.*, no. 21, with plate.

1952 Balazs, J. Notes on BT Lyrae and on two new variables near M 56. *Sternw. Ungar. Akad. Wiss. Budapest Mitt.*, no. 30.

1953 Sawyer, H. B. Thirty-eight new variable stars in eleven globular clusters. *R. A. S. C. Jour.*, v. 47, pp. 229–236; *Dunlap Comm.*, no. 34.

1961 Rosino, L. Osservazioni di due variabili peculiari e d'una variabile tipo RR Lyrae en ammassi stellare. *Accad. Patavina SS LL AA Mem.*, v. 74, 1960–61; *Asiago Cont.* no. 117.

1928*a* Ludendorff, 1943 Payne-Gaposchkin, Brenton, Gaposchkin, 1947 Fricke, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1948*I* Sawyer, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1950 Kurth, 1951*II* Kurth, 1952*Iabcd* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953 *ei* Rosino, 1953 Sawyer, 1953 Shapley and McKibben, 1954 Bidelman, 1954 Blamont, 1954 Gingerich, 1954 Perek, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*b* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1958 Maffei (photo), 1958*II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Id, IIai* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfik* Kron and Mayall, 1960 Kurth, 1960*acf* Wilkens, 1961*b* Haffner, 1961 Hénon, 1961*I, IIa* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962 Sawyer Hogg.
See also: 7078 1957 Izsak.

Palomar 10 α 19^h 16^m.0, δ + 18° 28′ l^{II}52°.44, b^{II} + 02°.68

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory sky survey. *A. S. P. Pub.*, v. 67, pp. 258–261. (Discovery by A. G. Wilson).

1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1958 Rosino, 1959*Ip* Sawyer Hogg, 1961*III* Sawyer Hogg, 1962*I* Rosino.

NGC 6809 (Messier 55) α 19^h 36^m.9, δ − 31° 03′ l^{II}08°.83, b^{II} − 23°.28

1951 King, I. New variables and periods in the globular cluster Messier 55. *Harv. Bull.*, no. 920.

1928*b* Ludendorff, 1935 Walters, 1947*abcd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1950*d* Becker, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Gingerich, 1953 Kholopov, 1953*d* Rosino, 1954 Cimino, 1954 Gingerich, 1954 Markarian, 1954*I* Zagar, 1955*IIbd* Sawyer, 1955*IIa* Struve, 1956*c* Baum, 1956 van

NGC 6809 (cont'd)

den Bergh, 1956*a* Schmidt, 1957 van den Bergh, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1958 Náprstková, 1959 van Agt and Oosterhoff, 1959 Johnson, 1959*Iad, IIad* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959*Iip* Sawyer Hogg, 1960 Gingerich, 1960*acfikl* Kron and Mayall, 1960*bcg* Wilkens, 1961 Hénon, 1961*I, III* Sawyer Hogg, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

Palomar 11 α 19h 42m.6, δ − 08° 09′ l^{II}31°.79, b^{II} − 15°.60

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory sky survey. *A. S. P. Pub.*, v. 67, pp. 258–261. (Discovery by A. G. Wilson).

1962 Kinman, T. D., and Rosino, L. Notes on faint star clusters. *A. S. P. Pub.*, v. 74, pp. 499–506. (May be rich galactic cluster).

1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1959*Ip* Sawyer Hogg, 1961*III* Sawyer Hogg, 1962*I* Rosino.

NGC 6838 (Messier 71) α 19h 51m.5, δ + 18° 39′ l^{II}56°.74, b^{II} − 04°.55

1928 Baade, W. Untersuchung von zwei Milchstrassenfeldern auf Veränderliche (124 neue Veränderliche). *A. N.*, v. 232, pp. 65–70.

1941 Cuffey, J. The galactic cluster NGC 6838. *Am. A. S. Pub.*, v. 10, p. 122.

1952 Sawyer, H. B. Variable stars in the globular cluster NGC 6838. *A. J.*, v. 57, p. 26.

1954 Becker, W. Bemerkung zum Farben-Helligkeits-Diagramm des Kugelhaufens M 71 = NGC 6838. *Z. f. Ap.*, v. 34, pp. 107–109; *Ast.-Met. Anstalt Univ. Basel Mitt., Astr. Reihe*, no. 1.

1954 Rosino, L. Ricerche sugli ammassi globulari XI. Su alcuni ammassi stellari di dubbia classificazione. *Asiago Cont.*, no. 52, with photo.

1956 Artjuchina, N. M. Die Eigenbewegungen von Sternen in der Umgebung der Haufen M 71 und H 20. *Astr. Sternberg-Inst. Pub.*, v. 27, pp. 3–35. (Catalogue of 1372 stars).

1959 Cuffey, J. NGC 6838. *A. J.*, v. 64, p. 327. Summ., *Sky and Tel.*, v. 19, p. 93.

1960 Der ungewöhnliche Sternhaufen M 71. *Nachrichtenblatt der Vereinigung der Sternfreunde, Berlin*, v. 9, pp. 134–135.

1960 Messier 71. *Urania, København*, v. 17, pp. 15–16.

1961 Stephenson, C. B. Possible M-star members of NGC 6838. *A. J.*, v. 66, pp. 85–87, with plate.

1947 Parenago, 1947*abcd* (photo, error in cluster no.) Sawyer, 1948*a* Perek, 1953 Dreyer, 1953 Sawyer, 1954 Gingerich, 1954 Perek, 1954*I* Zagar, 1955*IIbcd* Sawyer, 1956*a* Morgan, 1956*a* Schmidt, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1958 Maffei (photo), 1958*Ia, II* Sawyer Hogg, 1959*Id, IIi, III* Kinman, 1959*a* Larsson-Leander, 1959*bc* Morgan, 1959 Sandage, 1959*Igip* Sawyer Hogg, 1960 Bowen, 1960 Ikhsanov, 1960*acdfik* Kron and Mayall, 1960 Sandage and Wallerstein, 1960*bcg* Wilkens, 1961*a* Haffner, 1961 Lohmann, 1961 Preston, 1961*I, III* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.
See also: 5272 1953 Sandage.

NGC 6864 (Messier 75) $\alpha\ 20^h\ 03^m.2,\ \delta - 22°\ 04'$ $l^{II}20°.31,\ b^{II} - 25°.76$

1928*a* Ludendorff, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*ade* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*ad* Rosino, 1954 Blamont, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956 Baum, 1956 van den Bergh, 1956*b* Schmidt, 1957 Rosino, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1958*II* Sawyer Hogg, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Iabd, IIbi* Kinman, 1959 Matsunami *et al.*, 1959*Icip* Sawyer Hogg, 1960*acdefik* Kron and Mayall, 1960 Kurth, 1960*b* Roberts, 1960*bcg* Wilkens, 1961 Hénon, 1961*I, III* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6934 $\alpha\ 20^h\ 31^m.7,\ \delta + 07°\ 14'$ $l^{II}52°.10,\ b^{II} - 18°.88$

1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948 Fehrenbach (error in no.), 1948*b* Perek, 1948*I* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953*d* Rosino, 1954 Blamont, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*b* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*I, II* Kinman, 1958*II* Sawyer Hogg, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Id, IIi* Kinman, 1959 Matsunami *et al.*, 1959*Iip, III* Sawyer, 1960*acfik* Kron and Mayall, 1960 Kurth, 1960*bcg* Wilkens, 1961*I, III* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962 Sawyer Hogg.

NGC 6981 (Messier 72) $\alpha\ 20^h\ 50^m.7,\ \delta - 12°\ 44'$ $l^{II}35°.15,\ b^{II} - 32°.68$

1953 Rosino, L. Ricerche sugli ammassi globulari IX. Osservazioni fotografiche di variabili e determinazione dei periodi e curve di luce di 16 cefeidi appartenenti all'ammasso globulare M 72. *Univ. Bologna Oss. Pub.*, v. VI, no. 2, pp. 49–64.

1953 Sawyer, H. B. Thirty-eight new variable stars in eleven globular clusters. *R. A. S. C. Jour.*, v. 47, pp. 229–236; *Dunlap Comm.*, no. 34.

1957 Nobili, F. Elementi e curve di luce di tre stelle variabili nell'ammasso globulare M 72. *Soc. Astr. Ital. Mem.*, v. 28, no. 1–2, pp. 141–145; *Asiago Cont.*, no. 83.

1928*a* Ludendorff, 1946 Miczaika, 1947 Parenago, 1947*abcd* Sawyer, 1948 Becker, 1948*b* Perek, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953*defi* Rosino, 1953 Sawyer, 1954 Gingerich, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*b* Schmidt, 1957 van den Bergh, 1958 Alter, Ruprecht, Vanýsek, 1958*e* Arp, 1958*I, II* Kinman, 1958 Maffei (photo), 1958*I* Sandage, 1958*II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959*Id, IIi* Kinman, 1959 Kurochkin, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959 Preston, 1959*Iip* Sawyer Hogg, 1960*acdefik* Kron and Mayall, 1960 Kurth, 1960*bceg* Wilkens, 1961*b* Haffner, 1961 Hénon, 1961 Payne-Gaposchkin, 1961*I* Sawyer Hogg, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 7006 $\alpha\ 20^h\ 59^m.1,\ \delta + 16°\ 00'$ $l^{II}63°.77,\ b^{II} - 19°.39$

1954 Sandage, A. R. Variable stars found by Edwin Hubble in the globular cluster NGC 7006. *A. S. P. Pub.*, v. 66, pp. 324–326; *Die Sterne*, v. 31, p. 187.

1955 Rosino, L., and Mannino, G. Ricerche sugli ammassi globulari XII. Distanza e stelle variabili d'un remotissimo ammasso globulare: NGC 7006. *Asiago Cont.*, no. 59, with plate.

1956 Lidt om Kuglehoben N.G.C. 7006. *Urania, København*, v. 13, pp. 57–58.

1957 Mannino, G. Periodi e curve di luce di 19 stelle variabili del tipo RR Lyrae dell'ammasso globulare NGC 7006. *Soc. Astr. Ital. Mem.*, v. 28, no. 3; *Asiago Cont.*, no. 84.

NGC 7006 (cont'd)

1928*a* Ludendorff, 1947 Parenago, 1947*abd* Sawyer, 1948 Becker, 1948*b* Perek, 1948*I* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd, II* Lohmann, 1953 Dreyer, 1953 Lohmann, 1953*cd* Rosino, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*b* Schmidt, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1958*I, II* Kinman, 1958 Rosino, 1958*II* Sawyer Hogg, 1959 van Agt and Oosterhoff, 1959 Dufay and Bigay, 1959 Dzigvashvili, 1959 Johnson, 1959*Id, IIi, III* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959*Icip, IIc* Sawyer Hogg, 1960*acfikl* Kron and Mayall, 1960 Kurth, 1960*bceg* Wilkens, 1961*a* Haffner, 1961 Kurochkin, 1961*I, III* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962 Sawyer Hogg.

NGC 7078 (Messier 15) $\alpha\ 21^h\ 27^m\!.6,\ \delta + 11°\ 57'$ $l^{II} 65°.02,\ b^{II} - 27°.32$

1949 Sawyer, H. B. The early discovery of four globular clusters. *R. A. S. C. Jour.*, v. 43, p. 45.

1950 Rosino, L. Twenty-nine new variable stars in the globular cluster M 15. *Ap. J.*, v. 112, p. 221, with plate.

1951 Brown, A. The color magnitude array for stars in the globular cluster M 15. *Ap. J.*, v. 113, pp. 344–366; Abs., *A. J.*, v. 55, p. 165.

1951 Johnson, H. L., and Schwarzschild, M. On the color-magnitude diagram for M 15. *Ap. J.*, v. 113, pp. 630-636.

1952 Izsak, I. Three new variable stars in the globular cluster M 15. *Budapest Mitt.*, no. 28 (plate).

1955 Arp, H. C. Cepheids of period greater than one day in globular clusters. *A. J.*, v. 60, pp. 1–17.

1955 Kholopov, P. N. The space distribution of red giants and variable stars of RR Lyrae type in the globular cluster M 15. *Var. Stars* (Russ.), v. 10, no. 5, pp. 253–261.

1956 Mannino, G. Le stelle variabili dell'ammasso globulare M 15. I. Studio di 14 cefeidi del tipo RR Lyrae (N. 2–15). *Soc. Astr. Ital. Mem.*, v. 27, no. 2; *Asiago Cont.*, no. 74.

1956 Mannino, G. Le stelle variabili dell'ammasso globulare M 15. II. Studio di 10 note cefeide del tipo RR Lyrae (N. 17, 18, 22, 24, 30, 32, 35, 38, 39, 40) e di una nuova variabilie (N. 99). *Soc. Astr. Ital. Mem.*, v. 27, no. 3; *Asiago Cont.*, no. 75.

1956 Grubissich, C. Le stelle variabili dell'ammasso globulare M 15. III. Studio delle dieci variabili No. 19, 23, 25–29, 31, 42, 43. *Soc. Astr. Ital. Mem.*, v. 27, p. 3; *Asiago Cont.*, no. 76.

1956 Pallas and M 15. *Sky and Tel.*, v. 15, p. 444.

1957 Izsak, I. Untersuchungen über die Periodänderungen der Veränderlichen im Kugelsternhaufen M 15. Konferenz über Veranderliche Sterne, Budapest, 1956, 63–69; *Stern. Ungar. Akad. Wiss. Mitt.*, no. 42.

1957 Nobili, F. Le stelle variabili dell'ammasso globulare M 15. IV. Studio delle otto variabili N. 1, 44, 50–54, 66. *Soc. Astr. Ital. Mem.*, v. 28, nos. 1–2, pp. 105–120; *Asiago Cont.*, no. 81.

1958 Bachmann, G. Die Periode des Veränderlichen Nr. 19 im Kugelhaufen M 15. *A. N.*, v. 284, p. 191; *Berlin-Babelsberg Mitt.*, no. 7.

1958 Notni, P., and Oleak, H. Der Lichtwechsel von 25 Veränderlichen des Kugelhaufens M 15. *A. N.*, v. 284, pp. 49–56.

NGC 7078 (cont'd)

1959 Bronkalla, W. Periodenänderungen von RR Lyrae-Sterne in Kugelhaufen. *Remeis-Sternw. Bamberg Kl. Veröff.*, no. 27, p. 28.

1959 Mannino, G. Sulla variabile N. 99 dell'ammasso globulare M 15. *Soc. Astr. Ital. Mem.*, v. 30, no. 3–4; *Asiago Cont.*, no. 110.

1960 Bronkalla, W. Die Periodenänderungen von 27 Veränderlichen des Kugelhaufens M 15. *Berlin-Babelsberg Mitt.*, no. 10; *A. N.*, v. 285, pp. 181–190, 1960.

1961 King, I. Star distribution in the globular cluster M 15. *A. J.*, v. 66, pp. 47–48. See also, Globular cluster densities, *Sky and Tel.*, v. 21, pp. 210–211.

1961 Preston, G. W. Low-dispersion spectra of RR Lyrae stars in globular clusters. *Ap. J.*, v. 134, no. 2, pp. 651–652; *Lick Cont.*, no. 119.

1961 Tsoo, Yu-hua. Three new variable stars in the globular cluster Messier 15. *Acta Astr. Sinica*, v. 9, no. 1, 2, pp. 70–71, with plate.

1928*a* Ludendorff, 1935 Walters, 1938*ac* Payne-Gaposchkin and Gaposchkin, 1946 Miczaika, 1947 Parenago, 1947*abcd* Sawyer, 1948 BAAJ, 1948 Becker, 1948 Gamalej, 1948*b* Perek, 1948*I* Sawyer, 1949 Gialanella, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1949*cdef* Shapley, 1950*cdfg* Becker, 1950 Kurth, 1950 Stebbins, 1951*I*, *II* Kurth, 1952 Camm, 1952*Iabd* Lohmann, 1953*b* Deutsch, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1953*dfi* Rosino, 1953 Shapley and McKibben, 1954 Blamont, 1954 Cimino, 1954 Gingerich, 1954*a* Payne-Gaposchkin, 1954*b* Rosino, 1954*a* Sandage, 1954*I* Zagar, 1955*I*, *II* Arp, 1955 von Hoerner, 1955*II* Reddish, 1955*I*, *IIbcd* Sawyer, 1956*ac* Baum, 1956 van den Bergh, 1956 Kourganoff, 1956*cd* Morgan, 1956 Roberts, 1956*ab* Schmidt, 1957 van den Bergh, 1957 Ferrari d'Occhieppo, 1957 Kholopov, 1957 Rosino, 1957 Stohl, 1958 Alter, Ruprecht, Vanýsek, 1958*abdej* Arp, 1958 Burbidge and Sandage, 1958 Heckmann, 1958 Kholopov, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1958 Náprstková, 1958 Rosino, 1958*I*, *II* Sandage, 1958*Ieh*, *II* Sawyer Hogg, 1958 Wallerstein, 1959 van Agt and Oosterhoff, 1959 Dzigvashvili, 1959 Johnson, 1959*Iabd*, *IIabefhij* Kinman, 1959 Kurochkin, 1959 Matsunami *et al.*, 1959*ab* Morgan, 1959 Preston, 1959*Ifgijklop*, *IIa*, *III* Sawyer Hogg, 1960 Bowen, 1960*acdfgijkl* Kron and Mayall, 1960 Kurth, 1960 Markarian, 1960 Pavlovskaya, 1960*bh* Roberts, 1960 Sandage and Wallerstein, 1960*bcg* Wilkens, 1961*ab* Haffner, 1961 Hénon, 1961 Payne-Gaposchkin, 1961 Slettebak, Bahner and Stock, 1961*I*, *III* Sawyer Hogg, 1962*I*, *IIe* Arp, 1962 van den Bergh and Henry, 1962 Eggen and Sandage, 1962 Fernie, 1962 King, 1962 Kinman, 1962*II* Rosino, 1962*I* Sandage, 1962 Sawyer Hogg.

See also: 6779 1949 Rosino, 6341 1953 Arp, Baum, Sandage, 5272 1953 Sandage, 6205 1954 Baum, 5272 1954 Sandage, 6205 1955 Brown, 5272 1955 Roberts and Sandage, 104 1957 Gascoigne and Burr, 6656 1959 Arp and Melbourne, 5272 1959 Oort and van Kerk, 6522 1961 Whitford, 6712 1962 Smith and Sandage, 6356 1962 Wallerstein.

NGC 7089 (Messier 2) α 21^h 30^m.9, δ − 01° 03′ l^{II}53°.37, b^{II} − 35°.78

1897 *Soc. Astr. Fr. Bull.*, Dec., p. 485. (New variable by Chèvremont).

1949 Sawyer, H. B. Two RV Tauri-type variables in globular clusters. *R. A. S. C. Jour.*, v. 43, pp. 38–44; *Dunlap Comm.*, no. 18.

1949 Sawyer, H. B. The early discovery of four globular clusters. *R. A. S. C. Jour.*, v. 43, p. 45.

1955 Arp, H. C. Cepheids of period greater than one day in globular clusters. *A. J.*, v. 60, pp. 1–17.

1956 Arp, H. C., and Wallerstein, G. Cepheids in M 2. *A. J.*, v. 61, p. 272.

NGC 7089 (cont'd)

1956 Kreiken, E. A. A statistical study of pulsating stars. VII. The variables in M 2. *Dept. Astr. Univ. Ankara Comm.*, no. 14, pp. 79–82.

1957 Wallerstein, G. Note on the behavior of the RV Tauri-type star No. 11 in Messier 2. *A. J.*, v. 62, p. 168.

1961 Kulikov, V. I. Variable stars in the globular cluster M 2. *Var. Stars* (Russ.), v. 13, no. 6, pp. 400–406.

1961 Mantegazza, G. Fabbri. Periodi di 4 stelle variabili del tipo RR Lyrae dell' ammasso globulare NGC 7089. *Univ. Bologna Oss. Pub.*, v. 8, no. 5.

1935 Walters, 1947 Fricke, 1947 Parenago, 1947*abcd* Sawyer, 1948 BAAJ, 1948 Becker, 1948 Gamalej, 1948*b* Perek, 1948*II* Sawyer, 1949 Gialanella, 1949 Joy, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1950*df* Becker, 1950 Kurth, 1950 Stebbins, 1951*I*, *II* Kurth, 1951*b* Payne-Gaposchkin, 1952*Iabd* Lohmann, 1953*b* Deutsch, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1953*dj* Rosino, 1953 Shapley and McKibben, 1954 Bidelman, 1954 Blamont, 1954 Cimino, 1954 Gingerich, 1954*b* Payne-Gaposchkin, 1954*a* Sandage, 1954*I* Zagar, 1955*I*, *II* Arp, 1955 von Hoerner, 1955*II* Reddish, 1955*IIbcd* Sawyer, 1956*ac* Baum, 1956 van den Bergh, 1956 Kourganoff, 1956 Roberts, 1956*ab* Schmidt, 1957 van den Bergh, 1957 Ferrari d'Occhieppo, 1958 Alter, Ruprecht, Vanýsek, 1958*abej* Arp, 1958 Burbidge and Sandage, 1958*I*, *II* Kinman, 1958 Lohmann, 1958*I*, *II* Sandage, 1958*Ie* Sawyer Hogg, 1958 Wallerstein, 1959 van Agt and Oosterhoff, 1959*abcd* Arp, 1959 Dzigvashvili, 1959 Johnson, 1959*Iabd*, *IIabfhij* Kinman, 1959 Matsunami *et al.*, 1959*b* Morgan, 1959 Payne-Gaposchkin, 1959 Sandage, 1959*Iikp* Sawyer Hogg, 1960 Kron, 1960 *acfgijkl* Kron and Mayall, 1960 Kurth, 1960*h* Roberts, 1960 Markarian, 1960 Sandage and Wallerstein, 1960 Wallerstein and Carlson, 1960*bcg* Wilkens, 1961*ab* Haffner, 1961 Hénon, 1961 Lohmann, 1961 Payne-Gaposchkin, 1961*I*, *III* Sawyer Hogg, 1962*I* Arp, 1962 Bahner, Hiltner and Kraft, 1962 van den Bergh and Henry, 1962 Fernie, 1962*II* Rosino, 1962*I*, *II* Sandage, 1962 Sawyer Hogg.

See also: 5272 1947 Lohmann, 6205 1954 Baum, 5272 1954 Sandage, 5904 1958 Wallerstein, 6656 1959 Arp and Melbourne, 5272 1961 Smak, 6522 1961 Whitford, 6397 1961 Woolley *et al.*

NGC 7099 (Messier 30) $\alpha\ 21^h\ 37^m\!.5,\ \delta\ -23°\ 25'$ $l^{II}27°.16,\ b^{II}\ -46°.83$

1949 Rosino, L. Ricerche sugli ammassi globulari. I. Distribuzione e variabilita delle stelle dell'ammasso M 30 e valutazione della sua distanza. *Univ. Bologna Oss. Pub.*, v. V, no. 9, with plate. Summ., *Sternenwelt*, v. 3, p. 109, 1951.

1961 Rosino, L. Osservazioni di due variabili peculiari e d'una variable tipo RR Lyrae en ammassi stellare. *Accad. Patavina di SS LL AA Mem.*, v. 74, 1960–61; *Asiago Cont.*, no. 117.

1915 Stone, 1940 Shapley and Paraskevopoulos, 1947 Parenago, 1947 *abcd*Sawyer, 1948 Becker, 1948*b* Perek, 1949*abcde* Parenago, Kukarkin, Florja, 1952*Iabde* Lohmann, 1953 Dreyer, 1953 Kholopov, 1953 Lohmann, 1953*bcefi* Rosino, 1954 Blamont, 1954 Cimino, 1954 Gingerich, 1954*b* Rosino, 1954*I* Zagar, 1955 von Hoerner, 1955*IIbcd* Sawyer, 1956*c* Baum, 1956 van den Bergh, 1956*ab* Schmidt, 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958*I*, *II* Kinman, 1958 Maffei (photo), 1959 van Agt and Oosterhoff, 1959 Dzigvashvili, 1959 Johnson, 1959*Iabd*, *IIbi*, *III* Kinman, 1959 Matsunami *et al.*, 1959*Iip* Sawyer Hogg, 1960*acfikl* Kron and Mayall, 1960 Kurth, 1960*bcg* Wilkens, 1961 Hénon, 1961*I* Sawyer Hogg, 1962 van den Bergh and Henry, 1962 Fernie, 1962 Sawyer Hogg.

Palomar 12 $\alpha\ 21^h\ 43^m\!.7,\ \delta\ -21°\ 28'$ $l^{II}30°.52,\ b^{II}\ -47°.64$

1955 Abell, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory sky survey. *A. S. P. Pub.*, v. 67, pp. 258–261. (Discovery by Harrington and Zwicky).

Palomar 12 (cont'd)

1957 Zwicky, F. Morphological Astronomy. Springer-Berlin. Page 205, Dwarf galaxy in Capricorn (photo). Identification of first variable.
1962 Kinman, T. D., and Rosino, L. Notes on faint star clusters. *A. S. P. Pub.*, v. 74, pp. 499–506, with print.

1958 Alter, Ruprecht, Vanýsek, 1958 Burbidge and Sandage, 1958 Heckmann, 1959*Ip* Sawyer Hogg, 1961*III* Sawyer Hogg, 1962 Kinman, 1962*I* Rosino.

Palomar 13 $\alpha\ 23^h\ 04^m\!.2,\ \delta + 12°\ 28'$ $l^{II}87°.07,\ b^{II} - 42°.72$

1955 Wilson, A. G. Sculptor-type systems in the local group of galaxies. *A. S. P. Pub.*, v. 67, pp. 27–29. (Discovery by Wilson).
1957 Rosino, L. Sopra due ammassi globulari del catalogo di Abell (no. 4 e no. 13). *Asiago Cont.*, no. 85, with plate.

1955 Abell (No. 13), 1957 Rosino, 1958 Alter, Ruprecht, Vanýsek, 1958 van den Bergh, 1958 Burbidge and Sandage, 1958 Heckmann, 1958*II* Sawyer Hogg, 1959*Iip*, *III* Sawyer Hogg, 1961*I*, *III* Sawyer Hogg, 1962 Kinman, 1962*I* Rosino, 1962 Sawyer Hogg.
See also: Pal 1 1962 Kinman and Rosino.

NGC 7492 $\alpha\ 23^h\ 05^m\!.7,\ \delta - 15°\ 54'$ $l^{II}53°.32,\ b^{II} - 63°.46$

1957 Cuffey, J. Color-magnitude relations in Messier 53 and N.G.C. 7492. *A. J.*, v. 62, p. 91.
1961 Cuffey, J. NGC 7492. *M. N.*, v. 122, pp. 363–370; Summ., *Quarterly Jour.*, v. 2, no. 3, p. 222.
1962 Kinman, T. D., and Rosino, L. Notes on faint star clusters. *A. S. P. Pub.*, v. 74, pp. 499–506.

1928*a* Ludendorff, 1947*abd* Sawyer, 1949*abde* Parenago, Kukarkin, Florja, 1949*ce* Shapley, 1952*Iabd* Lohmann, 1953 Dreyer, 1953*def* Rosino, 1954 Cuffey, 1954*I* Zagar, 1955*IIbd* Sawyer, 1956*c* Baum, 1957 Shapley, 1958 Alter, Ruprecht, Vanýsek, 1958 Heckmann, 1958 Maffei (photo), 1959 Johnson, 1959 Matsunami *et al.*, 1959 *Ibcip*, *III* Sawyer Hogg, 1960*bcg* Wilkens, 1961*a* Haffner, 1961*III* Sawyer Hogg, 1962 Kinman, 1962 Sawyer Hogg.
See also: Pal 5 1951 Rosino.

SECTION B

References

References which Pre-date Bibliography of 1947

1789 Wollaston, F. *A General Catalogue of stars, nebulae and clusters of stars, whose positions have been ascertained by different astronomers, arranged in order of Right Ascension, in their respective zones of North Polar Distance of January 1, 1790.*

1912 Knox-Shaw, H. Observations of nebulae made during 1909–1911. *Helwan Bull.*, no. 9, pp. 69–78.

1915 Knox-Shaw, H. Observations of nebulae made during 1912–1914. *Helwan Bull.*, no. 15, pp. 129–138.

1915 Stone, O. Southern Nebulae. *Leander McCormick Pub.*, v. 1, pt. 6, pp. 175–241. (Stone nos. 652, 656, 741, 825).

1921*I* Gregory, C. C. L. Third list of nebulae photographed with the Reynolds reflector. *Helwan Bull.*, no. 21, pp. 201–218.

1921*II* Gregory, C. C. L. Fourth list of nebulae photographed with the Reynolds reflector. *Helwan Bull.*, no. 22, pp. 219–235.

1928 Ludendorff, H. Die Veränderlichen Sterne. *Handbuch der Astrophysik*, v. 6, pp. 49–250.

a. Page 233. Veränderliche in kugelförmigen Sternhaufen.

b. Page 238. Veränderliche in der nächsten Umgebung von kugelförmigen Sternhaufen.

1928 Shapley, H. Studies of the galactic center. III. The absolute magnitudes of long period variables. *Nat. Acad. Sci. Wash. Proc.*, v. 14, pp. 958–962.

1935 Walters, M. H. H. *Globular clusters.* Neill & Co. Edinburgh, pp. 35.

1936 Kuiper, G. P. On the hydrogen content of clusters, binaries, and Cepheids. *Harv. Bull.*, no. 903, pp. 1–11.

1938 Payne-Gaposchkin, C. H., and Gaposchkin, S. *Variable Stars.* Cambridge. Chap. IV, The Cepheid variables, pp. 153–191.

a. Page 158. Table IV, V. Relation of light curve to period for variables in clusters.

b. Page 163. Table IV, VII. Light curve and period for Cepheids in extragalactic systems.

c. Page 165. Period luminosity relation.

1940 Oort, J. H. Some problems concerning the structure and dynamics of the galactic system and the elliptical nebulae NGC 3115 and 4494. *Ap. J.*, v. 91, pp. 273–306.

1940 Shapley, H., and Paraskevopoulos, J. S. Galactic and extragalactic studies. III. Photographs of thirty southern nebulae and clusters. *Nat. Acad. Sci. Wash. Proc.*, v. 26, pp. 31–36; *Harv. Repr.*, no. 184.

1941 Merrill, P. The radial velocities of long-period variable stars. Second paper. *Ap. J.*, v. 94, pp. 171–214.

1943 Payne-Gaposchkin, C., Brenton, V. K., and Gaposchkin, S. The variables of RV Tauri type. *Harv. Ann.*, v. 113, no. 1, pp. 1–65.

1944 Wallenquist, A., and Lundby, A. Integrated photographic magnitudes of twenty-four globular clusters in the Sagittarius and Ophiuchus regions. *Ark. Mat. Astr. Fys.*, v. 31, A. no. 6; *Astr. Obs. Uppsala Medd.*, no. 86.

References received after printing of Bibliography of 1947

1946 Miczaika, G. R. Die Periodenhäufigkeitsverteilung der kurzperiodischen Cepheiden in Kugelhaufen. *Bad. Landes Sternw. Heidelberg-Königstuhl Veröff.*, v. 14, no. 8, pp. 69–76.

1946 Vogt, H. Ueber die Auslösung der kurzperiodischen δ Cephei-veränderlichen in Kugelsternhaufen. *Bad. Landes Sternw. Heidelberg-Königstuhl Veröff.*, v. 14, no. 6, pp. 61–62.

1947 Fricke, W. Neuere Arbeiten über die Struktur kugelförmiger Sternhaufen. *Himmelswelt*, v. 55, pp. 34–36.

1947 von der Pahlen, E. Ueber die Entstehung der sphärischen Sternhaufen. *Z. f. Ap.*, v. 24, pp. 68–120; *Astrophys. Obs. Potsdam Mitt.*, no. 18.

1947 Parenago, P. P. The motions of globular clusters. *A. J. UdSSR*, v. 24, pp. 167–177.

1947 Sawyer, H. B. A bibliography of individual globular clusters. *Dunlap Pub.*, v. 1, no. 20. Ref., *Sky and Tel.*, v. 7, p. 203.
a. Pages 388–391. Catalogue of 99 globular clusters.
b. Page 392. Discoverers of globular clusters.
c. Page 395. Identification of Messier-Méchain with NGC numbers.
d. Page 396 *et seq.* References to individual globular clusters.

1948 BAAJ Messier's Catalogue. *B. A. A. Jour.*, v. 59, pp. 49–50.

1948 Becker, W. Bemerkungen über Farbe und Spektraltypus von Kugelhaufen. *Himmelswelt*, v. 55, pp. 177–179.

1948 Fehrenbach, C. Quelques mesures de magnitudes intégrales d'amas globulaires. *Haute-Provence Pub.*, Ser. A, no. 17; *Ann. d'Ap.*, v. 11, pp. 225–227.

1948 Gamalej, N. W. Eigenbewegungen von acht kugelförmigen Sternhaufen. *Pulkova Mitt.*, v. 17, no. 6, pp. 27–57.

1948 Joy, A. H. The spectra of the brighter variables in the globular clusters. *A. J.*, v. 53, pp. 113–114.

1948 King, I. The dynamics of globular clusters. *I. A. U. Trans.*, v. 7, pp. 410–411, 1950.

1948 Maitre, V. Répartitions des magnitudes, couleurs et masses dans les amas globulaires. *Jour. des Observateurs*, v. 31, pp. 129–137.

1948 Perek, L. Sur la rotation galactique des amas globulaires. *Ann. d'Ap.*, v. 11, pp. 185–192.
a. Page 185. Clusters excluded.
b. Pages 190–191. Table of velocities.

1948*I* Sawyer Hogg, H. Variable stars in globular clusters. *I. A. U. Trans.*, v. 7, pp. 408–409, 1950.

1948*II* Sawyer, H. B. Globular clusters of stars. *A. S. P. Leaflet*, no. 231.

1949 Gialanella, L. Sul problema dei due corpi di masse variabili in cui la forza attrativa e' proporzionale alla distanza. Applicazione agli ammassi globulari di stelle. *Soc. Astr. Ital. Mem.* (NS), v. 20, pp. 93–105; *Oss. Astr. Roma Monte Mario Cont. Sci.*, no. 145; Ref. *Math. Rev.*, v. 11, p. 408.

1949 Joy, A. H. Spectra of the brighter variables in globular clusters. *Ap. J.*, v. 110, pp. 105–116; *Mt. W. and Pal. Repr.*, no. 5.

1949 Kholopov, P. N. Ein numerisches Verfahren zur Bestimmung der räumlichen Sterndichte in einem elliptischen Sternhaufen. *A. J. UdSSR*, v. 26, no. 5, pp. 298–304; Ref. *Math. Rev.*, v. 11, p. 467.

1949 Parenago, P. P., Kukarkin, B. W., Florja, N. F. The system of globular clusters. *Astr. Sternberg-Inst. Trudy*, v. 16, pp. 47–70.
- *a.* Page 49. Moduli of 94 globular clusters.
- *b.* Page 53. Relation of absolute magnitude to concentration class.
- *c.* Page 56. Absorption for nine clusters.
- *d.* Pages 58–60. Diameters and absorption for globular clusters.
- *e.* Pages 67–68. Space co-ordinates of globular clusters.
- *f.* Page 69. Diagram of local cluster.

1949 Shapley, H. A half century of globular clusters. *Pop. Astr.*, v. 57, pp. 203–229; Summ., *Soc. Astr. Fr., Bull.*, v. 63, p. 224.
- *a.* Pages 203–205. Historical.
- *b.* Page 206. Special clusters.
- *c.* Pages 211–212. Distances and absolute magnitudes of 31 high latitude clusters.
- *d.* Pages 212–216. Spectral types and colours; star population of a new kind.
- *e.* Pages 217–220. Angular and linear diameters of 31 clusters.
- *f.* Pages 221–224. Variables in clusters.
- *g.* Page 242. Motions and structure.
- *h.* Page 227. Relation to other objects.

1950 Becker, W. *Sterne und Sternsysteme.* Dresden and Leipzig. Theodor Steinkopff. Die kugelförmigen Sternhaufen, pp. 164–174.
- *a.* Page 165. Photo NGC 6205.
- *b.* Page 166. Apparent diameters.
- *c.* Page 167. Ellipticities.
- *d.* Pages 168–169. Distances and physical data for 15 clusters.
- *e.* Pages 169–170. Star counts and stellar density.
- *f.* Pages 170–172. Colour-magnitude diagrams.
- *g.* Pages 172–174. Variables in clusters.

1950 Kurth, R. Massenabschätzung der kugelförmigen Stern- und Nebelhaufen auf dynamischer Grundlage. *Z. f. Ap.*, v. 28, pp. 1–16; *Ast. Inst. Univ. Bern. Veröff.*, no. 6.

1950 Shapley, H. Report of meeting of Commission 37, Star Clusters. *I. A. U. Trans.*, v. 7, pp. 407–413.

1950 Stebbins, J. The electrical photometry of stars and nebulae. *M. N.*, v. 110, pp. 416–428. Globular clusters, p. 420.

1951 Bok, B. J. Dynamics and evolution of star clusters. *Sky and Tel.*, v. 10, pp. 211–213, 239–240.
- *a.* Page 211. Photo ω Cen.
- *b.* Page 239. Photo NGC 4372.

1951*I* Kurth, R. Die Masse der Kugelsternhaufen. *Z. f. Ap.*, v. 29, pp. 26–28; *Ast. Inst. Univ. Bern Veröff.*, no. 8.

1951*II* KURTH, R. Die Entwicklung der Kugelsternhaufen. *Z. f. Ap.*, v. 29, pp. 33–65; *Ast. Inst. Univ. Bern Veröff.*, no. 9. Masses of globular clusters, p. 63.

1951 PAYNE-GAPOSCHKIN, C. The intrinsic variable stars, *Astrophysics*, ed. by J. A. Hynek, McGraw-Hill, pp. 495–525.
a. Pages 507–510. The cluster type stars.
b. Pages 510–514. The Type II Cepheids.
c. Page 513. Velocity curves.
d. Page 516. RV Tauri stars in globular clusters.
e. Page 519. Long-period variables in isolated systems.

1951 THACKERAY, A. D. Proceedings of Observatories, Radcliffe Observatory, Pretoria. *M. N.*, v. 111, pp. 206–208.

1952 BAADE, W. Report of president of Commission 37, Star Clusters. *I. A. U. Trans.*, v. 8, p. 596.

1952 CAMM, G. L. Self-gravitating star systems. II. *M. N.*, v. 112, pp. 155–176.

1952 JOHNSON, H. M. The forms, orientations, and masses of globular clusters. *Ap. J.*, v. 115, pp. 124–128.

1952 KHOLOPOV, P. N. The ellipticity of globular clusters. *A. J. UdSSR*, v. 29, pp. 671–681.

1952*I* LOHMANN, W. Die Entfernungen der kugelförmigen Sternhaufen. *Z. f. Ap.*, v. 30, pp. 234–247.
a. Page 238. Interstellar absorption for globular clusters.
b. Pages 242–243. Collection of distance moduli.
c. Pages 245–246. Comments on distance moduli.
d. Page 246. True distance moduli.

1952*II* LOHMANN, W. Bestimmung der Masse des Milchstrassensystems aus den Radialgeschwindigkeiten kugelförmigen Sternhaufen. *Z. f. Ap.*, v. 30, pp. 305–307.

1952*III* LOHMANN, W. Die kugelförmigen Sternhaufen. *Sternenwelt*, v. 4, pp. 134–142.
a. Page 142. Table of number of stars and total mass.
b. Photo.
c. Reference.

1953 DEUTSCH, A. J. Quelques problèmes sur le spectre des étoiles d'amas. Paris Conference, Principes Fondamentaux de Classification Stellaire. Centre National de la Recherche Scientifique. 1955.
a. Pages 32–37. Individual spectra reproduced in Fig. 15.
b. Page 35. Other clusters mentioned.

1953 DREYER, J. L. E. New General Catalogue of Nebulae and Clusters of Stars (1888), Index Catalogue (1895), Second Index Catalogue (1908). London, *Roy. Ast. Soc. Mem.*, 1953, 378 pp. Reprint, with corrections, of all material in original NGC, and two IC's.

1953 GINGERICH, O. Messier and his catalogue. *Sky and Tel.*, v. 12, pp. 255–257, 265, 288–291.

1953 KHOLOPOV, P. N. Die scheinbare Verteilung der Sterne in zwanzig kugelförmigen Sternhaufen. *Astr. Sternberg-Inst. Pub.*, v. 23, pp. 250–301; Summ., *Ast. News Letter*, no. 97, p. 35, 1959.

1953. LOHMANN, W. Die Durchmesser der kugelförmigen Sternhaufen. *Z. f. Ap.*, v. 32, pp. 298–302.

1953 ROSINO, L. Orientamenti e problemi nello studio degli ammassi globulari di stelle. *Univ. Bologna Oss. Pub.*, v. 6, no. 1, pp. 1–48. Reprint of articles from *Coelum.*

a. Page 1. Historical.
b. Page 6. Distances.
c. Page 9. Diameters.
d. Page 18. Distance table of 31 high latitude clusters.
e. Page 24. Classification types.
f. Tav. IV. Plates.
g. Page 25. Integrated brightness and linear diameter.
h. Page 31. Limiting magnitudes.
i. Page 34. Variable stars.
j. Page 42. H–R diagrams and evolution.

1953 SAWYER, H. B. Thirty-eight new variable stars in eleven globular clusters. *R. A. S. C. Jour.*, v. 47, pp. 229–236; *Dunlap Comm.*, no. 34.

1953 SHAPLEY, H., and MCKIBBEN NAIL, V. Magellanic Clouds VI. Revised distances and luminosities. *Nat. Acad. Sci. Wash. Proc.*, v. 39, no. 5, pp. 349–362; *Harv. Repr.*, no. 372. The brighter variable stars in 13 globular clusters, pp. 351–352.

1954 BELSERENE, E. P. The period-amplitude relation in globular clusters. *A. J.*, v. 59, pp. 406–409.

1954 BIDELMAN, W. P. Catalogue and bibliography of emission-line stars of types later than B. *Ap. J. Supp.*, v. 1, no. 7, pp. 175–268. Intrinsic variables of types F, G, and K, p. 205.

1954 BLAMONT, J-E., and COURTÈS, G. Polarization des amas globulaires. *Ann. d'Ap.*, v. 17, pp. 312–313; *Haute-Provence Pub.*, v. 3, no. 14. Ref., *Pop. A. Tids.*, v. 37, p. 76, 1956.

1954 CIMINO, M. Sulla distribuzione de equilibrio della materia gassosa negli ammassi globulari. *Rend. Accad. Nazionale Lincei Cl. Sci. fis., mat. nat.* (8) v. 16, pp. 215–221; *Oss. Astr. Roma Monte Mario Cont. Sci.* (NS) no. 201.

1954 CUFFEY, J. Distribution of globular clusters in high north and south galactic latitude. *A. J.*, v. 59, pp. 319–320.

1954 GINGERICH, O. Observing the Messier catalogue. *Sky and Tel.*, v. 13, pp. 157–159.

1954 HUANG, S-S. A note on globular clusters. *A. J.*, v. 59, pp. 241–243; *Berkeley Repr.*, no. 67.

1954 MARKARIAN, B. E. Ueber die Entwicklung der offenen Sternhaufen. *Bjurakan Obs. Mitt.*, no. 12, 22 pp.

1954 PAYNE-GAPOSCHKIN, C. *Variable stars and galactic structure.* University of London.

a. Page 20. Distribution of periods of RR Lyrae stars.
b. Page 38. The W Virginis stars (Population II Cepheids).

1954 PEREK, L. A note on the galactic orbits of globular clusters. *Astr. Inst. Brno Cont.*, v. 1, no. 12, pp. 1–10.

1954 ROSINO, L. Le Popolazioni Stellari. *Univ. Bologna Oss. Pub.*, v. 6, no. 4.

a. Figs. 2, 3, 4. Colour-magnitude diagrams.
b. Pages 8–16. Discussion of variables.

1954 SANDAGE, A. R. A survey of present knowledge of globular clusters and its significance for stellar evolution. Les Processus Nucleaires dans les Astres. *Comm. Cinq. Colloque Internationale Liège*, 1953, *Inst. d'Astrophys. Univ. Liège Mem.*, v. 8, no. 357, pp. 254–274.
a. Page 255. Colour magnitude diagrams.
b. Page 259. Luminosity function.
c. Page 260. Evolutionary significance.
d. Page 272. Masses of cluster variables.

1954 SCHWARZSCHILD, M. Mass distribution and mass-luminosity ratio in galaxies. *A. J.*, v. 59, pp. 273–284.

1954 WOOLLEY, R. v. d. R. A study of the equilibrium of globular clusters. *M. N.*, v. 114, pp. 191–209.

1954*I* ZAGAR, F. Gli ammassi globulari di stelle. *Oss. Astr. Milano-Merate Cont.*, NS no. 50, pp. 1–24. Catalogue of 102 globular clusters.

1954*II* ZAGAR, F. Sulla stabilita degli ammassi globulari di stelle. *Oss. Astr. Milano-Merate Cont.*, NS no. 46, pp. 1–14.

1955 ABELL, G. O. Globular clusters and planetary nebulae discovered on the National Geographic Society–Palomar Observatory sky survey. *A. S. P. Pub.*, v. 67, pp. 258–261.

1955*I* ARP, H. C. Cepheids of period greater than one day in globular clusters. *A. J.*, v. 60, pp. 1–17, with prints.

1955*II* ARP, H. C. Color-magnitude diagrams for seven globular clusters. *A. J.*, v. 60, pp. 317–337.

1955 BAUM, W. A. The main sequence of population II. *A. S. P. Pub.*, v. 67, p. 114.

1955 VON HOERNER, S. Ueber die Bahnform der kugelförmigen Sternhaufen. *Z. f. Ap.*, v. 35, pp. 255–264.

1955 HOYLE, F., and SCHWARZSCHILD, M. On the evolution of type II stars. *Ap. J. Supp.*, v. 2, no. 13, pp. 1–40.

1955*I* REDDISH, V. C. The absolute magnitude of the RR Lyrae variables. *Obs.*, v. 75, pp. 124–125.

1955*II* REDDISH, V. C. The period-luminosity relation in population II. *M. N.*, v. 115, pp. 480–486.

1955*I* SAWYER, H. B. A summary of variable stars in globular star clusters. *R. A. S. C. Jour.*, v. 49, pp. 114–116.

1955*II* SAWYER, H. B. A second catalogue of variable stars in globular clusters, comprising 1,421 entries. *Dunlap Pub.*, v. 2, no. 2, pp. 33–93.
a. Page 36. Thirty-four globular clusters not searched for variables.
b. Pages 38–39. Summary of variables in 72 globular clusters.
c. Pages 43–45. Clusters containing variables not RR Lyrae stars.
d. Pages 48–93. Catalogue of variable stars in globular clusters.

1955*I* STRUVE, O. Globular clusters and their history. *Sky and Tel.*, v. 14, pp. 326–328.
a. Pages 326–327. Photos.
b. Pages 327–329. Structure and motion.

1955*II* STRUVE, O. More on globular clusters. *Sky and Tel.*, v. 14, pp. 366–369.
a. Pages 367–368. Large-scale photos.
b. Page 366. Small-scale photos.
c. Page 366. Position.
d. Pages 367–368. Absolute magnitudes.

1956 BAUM, W. A. Globular clusters observed through a crystal ball. New Horizons in Astronomy. *Smithsonian Cont. Astrophysics*, v. 1, pp. 165–175.
a. Pages 165–169. Discussion of colour-magnitude diagrams.
b. Page 169. Interesting clusters in low latitudes.
c. Page 170. Table of data on high latitude clusters.
d. Pages 170–172. Comparison of spectral differences.

1956 VAN DEN BERGH, S. The diameter of globular clusters. *Z. f. Ap.*, v. 41, pp. 61-65.
Table I. Cluster radii derived from the co-ordinates of cluster-type variables.

1956 HASELGROVE, C. B., and HOYLE, F. A preliminary determination of the age of type II stars. *M. N.*, v. 116, pp. 527–532.

1956 KOURGANOFF, V. Les galaxies. II, La galaxie. 2, Amas et associations stellaires. *Le Ciel et la Terre*, Paris.

1956 KREIKEN, E. A. A statistical study of pulsating stars. Sixth paper. Variables in miscellaneous clusters. *Fac. Sci. Univ. Ankara Comm.*, v. 8, no. 1; *Dept. Astr. Ankara Univ. Comm.*, no. 13, pp. 72–78.

1956 MORGAN, W. W. The integrated spectral types of globular clusters. *A. S. P. Pub.*, v. 68, pp. 509–516.
a. Page 511. Globular clusters of later type.
b. Pages 511–512. Other globular clusters near nucleus.
c. Pages 512–514. Classification of McDonald spectrograms.
d. Plate I, and page 515. Photos of integrated spectra.

1956 ROBERTS, M. S. A theoretical luminosity function for the elliptical nebula M 32. *A. J.*, v. 61, pp. 195–199.

1956 SCHMIDT, M. A model of the distribution of mass in the galactic system. *B. A. N.*, v. 13, no. 468, pp. 15–41.
a. Pages 36–37. The distribution of globular clusters, with distance components.
b. Page 38. Radial velocities and rotational components of globular clusters.

1956 WOOLLEY, R. v. D. R. The equilibrium of globular clusters. *Obs.*, v. 76, pp. 53–54.

1956 WOOLLEY, R. v. D. R., and ROBERTSON, D. A. Studies in the equilibrium of globular clusters. II. *M. N.*, v. 116, pp. 288–295.

1957 VAN DEN BERGH, S. RR Lyrae stars and galactic structure. *Perkins Cont.*, Ser. II, no. 9; *A. J.*, v. 62, pp. 334–339. Sec. 1. RR Lyrae stars in globular clusters.

1957 FERRARI D'OCCHIEPPO. Zur Periode-Radius-Beziehung der Delta Cephei-Sterne. *Univ. Sternw. Wien Mitt.*, v. 9, no. 7, pp. 143–152.

1957*I* VON HOERNER, S. Der innere Aufbau der Kugelsternhaufen. *A. G. Mitt.*, 1956, pp. 18–19.

1957*II* VON HOERNER, S. The internal structure of globular clusters. *Ap. J.*, v. 125, pp. 451–469.

1957 JOHNSON, H. L. The relation between U–B and absolute magnitude of F-type stars. *A. S. P. Pub.*, v. 69, pp. 404–408.

1957 KHOLOPOV, P. N. Density distribution of RR Lyrae variables in globular clusters and phenomena of stratification in these systems. *Var. Stars* (Russ.), v. 11, no. 3, pp. 202–209.

1957 POVEDA, A. La energia potencial de la esfera politropica $n = 5$. *Tonantzintla and Tacubaya Bol.*, no. 17, pp. 8–14.

1957 ROMAN, N. G. High velocity stars as Population I objects. *A. J.*, v. 62, p. 146.

1957 ROSINO, L. Problems of variable stars in globular clusters. Konferenz über Veränderliche Sterne, Budapest, 1956. *Mitt. Sternw. Ungar. Akad. Wiss.*, no. 42.

1957*I* SANDAGE, A. Observational approach to evolution. I. Luminosity functions. *Ap. J.*, v. 125, pp. 422–434.

1957*II* SANDAGE, A. Observational approach to evolution. II. A computed luminosity function for KO–K2 stars from Mv = +5 to Mv = −4.5. *Ap. J.*, v. 125, pp. 435–444.

1957 SELJACH, G. E. Die Berechnung der Massen der kugelförmigen Sternhaufen. *Abh. Shdanow-Staatsuniv. Leningrad*, no. 190 (*Math.* no. 29), pp. 52–58; *Astr. Obs. Leningrad Pub.*, v. 17, pp. 52–58.

1957 SHAPLEY, H. *The Inner Metagalaxy*. Yale Univ. Press. The thickness of our galaxy, pp. 167–169. (Clusters farthest from galactic plane).

1957 STOHL, J. Gul'ové hviezdokopy. (Globular star clusters). *Casopis*, v. 7, pp. 45–52.

1958 ALTER, G., RUPRECHT, J., and VANÝSEK, V. Catalogue of Star Clusters and Associations. Publishing House of the Czechoslovak Academy of Sciences, Prague. Individual cards of references and data for each cluster.

1958 ARP, H. C. The Hertzsprung-Russell Diagram. *Handbuch der Physik*, v. 51, pp. 75–133. The H–R diagram for globular clusters, pp. 107–123.
- *a.* Page 109, sec. 34, 35. RR Lyrae colours and gap.
- *b.* Page 110, sec. 36. Fit of colour-magnitude diagrams.
- *c.* Page 112, sec. 37. Stars off the main sequence.
- *d.* Page 112, sec. 38. Position of giant sequence.
- *e.* Page 113, sec. 39. Correlation with RR Lyrae periods.
- *f.* Page 113, sec. 40. Spectra and chemical abundances.
- *g.* Page 114, sec. 41. Observed main sequences.
- *h.* Page 116, sec. 42. Ultraviolet colour indices.
- *i.* Page 118, sec. 44. Zero point of absolute magnitude.
- *j.* Page 120, sec. 46. Cepheids in globular clusters.
- *k.* Page 123, sec. 49. Long period variables.
- *l.* Page 128, sec. 54. Population type and chemical composition.

1958 VAN DEN BERGH, S. Intergalactic globular clusters. *Obs.*, v. 78, p. 85.

1958 BURBIDGE, E. M., and BURBIDGE, G. Stellar evolution. *Handbuch der Physik*, v. 51, pp. 134–295. Sec. III. Colour-magnitude diagrams of globular clusters.
- *a.* Page 213. Colour-magnitude diagrams of globular clusters.
- *b.* Page 216. Luminosity functions of field stars and clusters.
- *c.* Page 234. Stellar evolution in the local group.

1958 BURBIDGE, E. M., and SANDAGE, A. Properties of two intergalactic globular clusters. *Ap. J.*, v. 127, pp. 527–538, with plates.

1958 HECKMANN, O. Report of commission on star clusters and associations. *I. A. U. Draft Report*, v. 10, pp. 360–361; *I. A. U. Trans.*, v. 10, pp. 575–590, 1960.

1958 KHOLOPOV, P. N. See the reference for 1957 Kholopov; Summ., *Ast. News Letter* no. 98, 1960.

1958*I* KINMAN, T. D. A revision of the distance moduli of the galactic globular clusters. *M. N. A. S. S. A.*, v. 17, no. 3, pp. 19–23; *Radcliffe Repr.*, no. 9.

1958*II* KINMAN, T. D. A revision of the distance moduli of seventy-five globular clusters. *Obs.*, v. 78, pp. 122–123.

1958 LEDOUX, P., and WALRAVEN, TH. Variable Stars. *Handbuch der Astrophysik*, v. 51, pp. 353–604.

a. Page 366. Form of light curves and relation to period.

b. Page 405. Long period variable stars.

c. Page 582. The RR Lyrae stars.

d. Page 583. The short period Cepheids in clusters, the W Virginis stars and the RV Tauri stars.

1958 MAFFEI, P. Venti anni di attivita della stazione astronomica dell' Universita di Bologna a Loiano. *Univ. Bologna Oss., Pub.*, v. 7, no. 1, pp. 1–58. Photographs with Loiano reflector.

1958 NÁPRSTKOVÁ, J. Globular clusters. *Říše hvězd*, v. 39, pp. 155–157.

1958 ROSINO, L. Ricerche astronomiche ed astrofisiche all' Osservatorio dell' Universita di Padova—Parte I. *Asiago Cont.*, no. 111; *La Ricerca Scientifica* anno 28, no. 6.

1958*I* SANDAGE, A. The color-magnitude diagrams of galactic and globular clusters and their interpretation as age groups. Conf. Stellar Populations, Vatican Obs., 1957. *Ric. Astr. Vaticano*, v. 5, pp. 41–68.

1958*II* SANDAGE, A. Luminosity function of galactic clusters, globular clusters, and elliptical galaxies. Conf. Stellar Populations, Vatican Obs., 1957. *Ric. Astr. Vaticano*, v. 5, pp. 75–93.

1958 SAURER, J.-M. Les amas globulaires. *Soc. Astr. Fr., Bull.*, v. 72, pp. 359–365.

1958*I* SAWYER HOGG, H. Globular star clusters. *R. A. S. C. Jour.*, v. 52, pp. 97–108.

a. Page 98. Recently added globular clusters.

b. Page 99. Intergalactic globular clusters.

c. Page 100. Surface brightness curve.

d. Page 101. Star counts.

e. Pages 102–103. Colour-magnitude diagrams.

f. Pages 102–105. Spectra.

g. Page 105. Direct photo and integrated spectrum.

h. Pages 104–106. Variables.

i. Pages 106–107. Motions.

1958*II* SAWYER HOGG, H. Report of president of Sub-commission 27b, Variable stars in globular clusters. *I. A. U. Draft Reports*, v. 10, pp. 242–245; *I. A. U. Trans.*, v. 10, pp. 424–427, 1960.

1958 VANDEKERKHOVE, E. The reddening of the extragalactic nebulae. *Obs.*, v. 78, pp. 206–211; *Obs. Roy. Belgique, Comm.*, no. 149, 1959.

1958 WALLERSTEIN, G. Note on the population II Cepheid region in the color-magnitude diagram of globular clusters. *Ap. J.*, v. 128, pp. 141–142.

1959 VAN AGT, S. L. TH., and OOSTERHOFF, P. TH. Observations of variable stars in the globular clusters NGC 4590 (M 68) and NGC 6266 (M 62). *Leiden Ann.*, v. 21, pt. 4, pp. 253–290. Section 4. The frequency distribution of the variables in NGC 4590 and NGC 6266 as compared with that in other globular clusters.

1959 ALTER, G., HOGG, H. S., RUPRECHT, J., and VANÝSEK, V. Catalogue of star clusters and associations, Supplement I. *Astr. Inst. Czechoslovakia, Bull.*, v. 10, no. 3, App.

1959 ARP, H. The absolute magnitudes, colors, and metal abundance of stars in globular clusters. *A. J.*, v. 64, pp. 441–447.
- *a.* Pages 441–442. General.
- *b.* Pages 442–444. Absolute magnitudes and colours.
- *c.* Pages 444–446. Metal abundance. Table I.
- *d.* Pages 446–447. Discussion.

1959 BAUM, W. A. The Hertzsprung-Russell diagrams of old stellar populations. I. A. U. Symposium no. 10, Aug. 1958; *Ann. d'Ap., Supp.*, no. 8, pp. 23–32, 1959.

1959 DUFAY, J., and BIGAY, J. H. Mesure photoélectrique des indices de couleur de 21 amas globulaires. *C. R. Acad. Sci. Fr.*, v. 248, no. 15, pp. 2162–2164; *Haute-Provence Pub.*, v. 4, no. 41.

1959 DZIGVASHVILI, R. M. The determination of parameters of the velocity distribution function for the globular clusters on the base of the maximum likelihood principle. *Abastumani Astrophys. Obs. Bull.*, no. 24, pp. 129–142.

1959 JOHNSON, H. L. The integrated magnitudes and colors of globular clusters. *Lowell Bull.*, v. 4, no. 99, pp. 117–121.

1959*I* KINMAN, T. D. Globular clusters. I. The radial velocities of southern globular clusters. *M. N.*, v. 119, no. 2, pp. 157–173; *Radcliffe Comm.*, no. 47.
- *a.* Page 160. Table III. Radial velocities from Cassegrain spectra.
- *b.* Page 168. Table V. A comparison of globular cluster velocities.
- *c.* Page 170. Table VII. Radial velocities from Newtonian spectra.
- *d.* Page 171. Table VIII. Velocities and distances for seventy globular clusters.

1959*II* KINMAN, T. D. Globular clusters. II. The spectral types of individual stars and of the integrated light. *M. N.*, v. 119, pp. 538–558.
- *a.* Page 540. Table Ia. Classification of spectra of globular cluster giants.
- *b.* Page 540. Table Ib. Spectral types for integrated Cassegrain spectra.
- *c.* Page 540. Table Ic. Spectral types for integrated Newtonian spectra.
- *d.* Plate 9. Representative spectra of cluster giants.
- *e.* Plate 10. Representative integrated cluster spectra.
- *f.* Pages 542–543. Composite colour-magnitude diagram.
- *g.* Pages 545–549. Metal line strengths in globular cluster giants.
- *h.* Pages 549–553. Interpretation of integrated spectra.
- *i.* Page 553. Table V. Spectral type and distance from galactic plane and galactic centre for 63 clusters.
- *j.* Page 557. Correlations of numbers of RR Lyrae stars.

1959*III* KINMAN, T. D. Globular clusters. III. An analysis of the cluster radial velocities. *M. N.*, v. 119, pp. 559–575.

1959 KRAFT, R. P., CAMP, D. C., and HUGHES, W. T. The hydrogen emission lines in population II variable stars. *Ap. J.*, v. 130, pp. 90–98; *Goethe Link Pub.*, no. 32; *McDonald Cont.*, no. 305.

1959 KRON, G. E., and MAYALL, N. U. Photoelectric photometry of galactic and extragalactic star clusters. *A. J.*, v. 64, pp. 428–431.

1959 KUROCHKIN, N. E. Period-amplitude diagram for the stars of RR Lyrae-type. *A. J. UdSSR* v. 36, pp. 816–824; Summ., *Ast. News Letter* no. 99, 1960.

1959 Larsson-Leander, G. The galaxy. *Second Conference on Co-ordination of Galactic Research.* I. A. U. Symposium no. 7. The galactic disk.
a. Page 35. Globular clusters.
b. Page 37. Long period variables.

1959 Matsunami, N., Obi, S., Shimoda, M., Takase, B., and Takebe, H. Evolution of globular clusters. *Ast. Soc. Japan, Pub.*, v. 11, no. 1, pp. 9–34. See also: Takase, B., Matsunami, N., and Shimoda, M. Note on the evolution of globular clusters. *Ast. Soc. Japan, Pub.*, v. 12, no. 2, pp. 293–296, 1960: *Tokyo Obs. Repr.*, no. 177; Ref., *Astr. Herald* v. 52, p. 178. Table of 94 globular clusters.

1959 Morgan, W. W. The integrated spectra of globular clusters. *A. J.*, v. 64, pp. 432–436.
a. Page 432. Introduction.
b. Page 434. Table I. Classification of spectra by groups.
c. Page 434. Nucleus-disk clusters.
d. Pages 435–436. Appendix and discussion.

1959 Payne-Gaposchkin, C. Cepheid variables and the period-luminosity relation. *Wash. Acad. Sci., Jour.*, v. 49, no. 10, pp. 333–350; *Harv. Repr.* no. 536.

1959 Preston, G. C. A spectroscopic study of the RR Lyrae stars. *Ap. J.*, v. 130, pp. 507–538.

1959 Preston, G. W., and Spinrad, H. On the intrinsic colors of the RR Lyrae stars. *A. S. P. Pub.*, v. 71, pp. 497–502.

1959 Sandage, A. Symposium: The differences among globular clusters. General discussion. *A. J.*, v. 64, pp. 447–450.

1959*I* Sawyer Hogg, H. Star clusters. *Handbuch der Physik*, v. 53, pp. 129–207.
a. Page 130. Historical.
b. Pages 168–170. Absolute magnitudes, colours, diameters, absorption.
c. Page 170. Structure and concentration class.
d. Pages 172–174. Distances.
e. Pages 174–177. Density distribution, luminosity function, photo NGC 6205.
f. Pages 146, 177–178. Colour-magnitude diagrams.
g. Page 179. Integrated spectra.
h. Page 181. Individual spectra.
i. Pages 181–184. Variables.
j. Pages 184–185. Planetary nebula, diffuse nebulosity.
k. Pages 185–187. Motions.
l. Pages 187–188. Radial velocities of individual stars.
m. Pages 188–190. Masses and densities.
n. Page 190. Evolution and age.
o. Page 192. Relation to elliptical galaxies.
p. Page 205. App. B. Catalogue of globular clusters.

1959*II* Sawyer Hogg, H. Variable stars in star clusters. *R. A. S. C. Jour.*, v. 53, pp. 97–108.
a. Page 97. Numbers of variables.
b. Page 98. Photo IC 1276.
c. Page 99. RR Lyrae stars.
d. Page 100. Slow variables.
e. Page 101. Variables in intergalactic clusters.

1959*III* Sawyer Hogg, H. The areas of difference among globular clusters. *A. J.*, v. 64, pp. 425–428.

1959 Spinrad, H. Photoelectric observations of RR Lyrae stars. *Ap. J.*, v. 130, pp. 539–559; *Berkeley Repr.*, no. 156.

1959 Struve, O. Observational data of interest in the study of stellar evolution. Modèles d'étoiles et évolution stellaire. *Univ. Liège Inst. d'Astrophy.* 8°; *Mem. Roy. Soc. Liège*, 5th Ser. v. 3, pp. 17–40.

1959 Thackeray, A. D. Comparison of globular clusters in the galaxy and in the Magellanic Clouds. *A. J.*, v. 64, pp. 437–441; *Radcliffe Repr.*, no. 14.
a. Pages 439–440. Brightest stars.
b. Page 441. Discussion.

1959 Wallerstein, G. The brightest main sequence star in M 67. *A. S. P. Pub.*, v. 71, pp. 451–454.

1959 Wilson, O. C. A color-magnitude diagram for late-type stars near the sun. *Ap. J.*, v. 130, pp. 496–499. (Comparison).

1960 Alter, G., Ruprecht, J., and Vanýsek, V. Catalogue of star clusters and associations, Supplement 2. *Astr. Inst. Czechoslovakia, Bull.*, v. 11, no. 1, App.

1960 Bowen, I. S. Annual report of the director, Mount Wilson and Palomar Observatories. *Carnegie Inst. Wash.*, *Year Book* 59. Globular and galactic clusters, pp. 17–18.

1960 Burbidge, G. R. The formation of stars by the condensation of diffuse matter. *Die Entstehung von Sternen*. Springer, Berlin. Chap. III. Associations and clusters, pp. 51–78.
a. Page 72. Colour-magnitude diagrams of globular clusters.
b. Page 73. Effect of chemical composition: fitting of main sequences of globular and galactic clusters.
c. Page 75. Horizontal branch stars in clusters.
d. Page 77. Luminosity functions of clusters.

1960 Chalonge, D. Détermination spectrophotométrique des types, des luminosités et des âges des étoiles. *Ann. d'Ap.*, v. 23, pp. 439–443. (Münch's comments on blue stars in M 13).

1960 Ebert, R., von Hoerner, S., and Temesváry, St. Die Entstehung von Sternen durch Kondensation diffuser Materie. *Die Entstehung von Sternen*. Springer, Berlin. Massenbestimmung, p. 240.

1960 Eggen, O. J. The two-colour relation for horizontal branch stars in globular clusters. *M. N. A. S. S. A.*, v. 19, no. 9, pp. 115–117.

1960 Feast, M. W., Thackeray, A. D., and Wesselink, A. J. The brightest stars in the Magellanic Clouds. *M. N.*, v. 121, no. 4, pp. 337–385. (Comparison of velocity determination with 47 Tuc, p. 341).

1960 Gingerich, O. Abbé Lacaille's list of clusters and nebulae. *Sky and Tel.*, v. 19, no. 4, pp. 207–208; *Harv. Repr.* Ser. II, no. 156.

1960*I* Hodge, P. W. Studies of the Large Magellanic Cloud. II. The globular cluster NGC 1846. *Ap. J.*, v. 132, pp. 341–345. (Giant branch similar to that of NGC 6356).

1960*II* Hodge, P. W. Studies of the Large Magellanic Cloud. III. The globular cluster NGC 1978. *Ap. J.*, v. 132, pp. 346–352. (Comparison).

1960*III* Hodge, P. W. Studies of the Large Magellanic Cloud. IV. The globular cluster Anonymous 4. *Ap. J.*, v. 132, pp. 351–353. (Comparison).

1960 IKHSANOV, R. N. Some problems of the interrelation of stars and nebulae and their evolution. *A. J. UdSSR*, v. 37, no. 4, pp. 642–658; *Soviet Astr. AJ*, v. 4, pp. 613–628, 1961.

1960 JOHNSON, H. L. On the determination of photometric distance moduli for star clusters. *Lowell Bull.*, v. 5, no. 2, pp. 17–22.

1960 KRON, G. E. Multiple color photometry. *Vistas in Astronomy*, vol. III, ed. A. Beer, pp. 171–183. Reddening, p. 179.

1960 KRON, G. E., and MAYALL, N. U. Photoelectric photometry of galactic and extragalactic star clusters. *A. J.*, v. 65, no. 10, pp. 581–620.

a. Page 586. Table IV. Magnitudes and related diameters of 67 galactic globular clusters.
b. Page 589. Table V. Comparison of infrared filters.
c. Page 590. Table VIa. Colours of star clusters in the galaxy.
d. Pages 598–599. Table VIII. Spectral types and comparison of spectral type estimates.
e. Page 599. Colour excess and absorption.
f. Page 601. Table X. Revised spectral types, colour excesses, and absorptions.
g. Page 604. Table XI. Comparison of colour excesses.
h. Page 604. Luminosities, colours, distances, diameters.
i. Page 605. Table XIII. App. moduli, luminosities, colours and magnitudes.
j. Page 606. Table XIV. Comparison of total abs. vis. magnitudes.
k. Page 608. Table XVII. Corrected moduli.
l. Page 617. Table XXI. Comparison of results for galactic globulars.
m. Page 617. Galactic centre.
n. Page 618. Addendum.

1960 KURTH, R. Ueber die Bahnformen der kugelförmigen Sternhaufen. *Z. f. Ap.*, v. 50, pp. 215–224.

1960 MARKARIAN, B. E. Discussion of the nature of population of star systems from partial luminosities. *Bjurakan Obs. Comm.*, v. 28, pp. 52–74.

1960 MORGAN, W. W. Yerkes Observatory and McDonald Observatory report. *A. J.*, v. 65, p. 577. Integrated spectra.

1960 PAVLOVSKAYA, E. D. The periods of short-period Cepheids in the direction to the galactic center. *Var. Stars* (Russ.), v. 13, no. 1, pp. 8–25.

1960 ROBERTS, M. S. Dust and gas in globular clusters. *A. J.*, v. 65, pp. 457–466, with plates. Summary, discussion, and photos, O. STRUVE, *Sky and Tel.*, v. 19, pp. 456–458, 1960.

a. Page 457. Obscuring matter.
b. Page 458. Table I. Globular clusters containing dark regions or lanes.
c. Page 458. Statistical fluctuations.
d. Figs. 1 and 2. Red and blue photos of globular clusters showing obscured regions.
e. Page 459. Mass of intraglobular clouds.
f. Page 460. Emission from possible H I and H II regions in globular clusters.
g. Page 461. Formation and removal of intraglobular matter.
h. Page 462. Effects on stellar population of a cluster.

1960 Sandage, A. R., and Eggen, O. J. Photometry in the Magellanic Clouds. III. The cluster NGC 1783. *M. N.*, v. 121, pp. 232–237. Composite diagram, p. 236.

1960 Sandage, A., and Wallerstein, G. Color-magnitude diagram for the disk globular cluster NGC 6356 compared with halo clusters. *Ap. J.*, v. 131, no. 3, pp. 598–609, with plates. Characteristics of many clusters, Table 4, p. 607.

1960 Wallerstein, G., and Carlson, M. On the ultraviolet excess in G dwarfs. *Ap. J.*, v. 132, pp. 276–277.

1960 Wilkens, H. Leuchtkraft und Durchmesser der Kugelhaufen. *Obs. Astr. Univ. Nacional La Plata, Circ.*, no. 16.
- *a.* Table Ia. Distance modulus for 54 clusters in positive galactic latitude.
- *b.* Table Ib. Distance modulus for 54 clusters in negative galactic latitude.
- *c.* Table 2a. 65 well observed clusters.
- *d.* Table 2b. 43 poorly observed clusters.
- *e.* Discussion.
- *f.* Table 3a. Determination of constant for 31 clusters, positive latitude.
- *g.* Table 3b. Determination of constant for 31 clusters, negative latitude.

1961 Alter, G., Hogg, H. S., Ruprecht, J., and Vanýsek, V. Catalogue of Star Clusters and Associations, Supplement 3. *Astr. Inst. Czechoslovakia, Bull.*, v. 12, no. 1, App. pp. 21.

1961 van den Bergh, S. The halo phase of galactic evolution. *A. S. P. Pub.*, v. 73, pp. 135–142.

1961 Haffner, H. Report of Commission 37. Star clusters and associations. *I. A. U. Trans.*, v. XI A, pp. 419–449.
- *a.* Table 3. Globular clusters photometrically studied.
- *b.* Special investigations.

1961 Hénon, M. Sur l'évolution dynamique des amas globulaires. *Ann. d'Ap.*, v. 24, no. 5, pp. 369–419. Pp. 42–45, Masses and radii.

1961 Kurochkin, N. E. RR Lyr type stars in the distant vicinities of globular clusters. *Var. Stars* (Russ.), v. 13, no. 4, pp. 248–254.

1961 Lohmann, W. Die Helligkeitsverteilungen in 16 kugelförmigen Sternhaufen. *Z. f. Ap.*, v. 53, no. 4, pp. 247–255.

1961 Michie, R. W. Structure and evolution of globular clusters. *Ap. J.*, v. 133, pp. 781–793; Summ., *A. J.*, v. 66, p. 49.

1961 Payne-Gaposchkin, C. The absolute magnitudes of RR Lyrae stars. *A. S. P. Pub.*, v. 73, pp. 100–102.

1961 Poveda, A. A mass-luminosity relation for dust-poor stellar systems. *Ap. J.*, v. 134, pp. 910–915.

1961 Preston, G. W. A coarse analysis of three RR Lyrae stars. *Ap. J.*, v. 134, pp. 633–649.

1961*I* Sawyer Hogg, H. Star clusters with variable stars. *A. S. P. Leaflet*, no. 385.

1961*II* Sawyer Hogg, H. The role of star clusters in our understanding of the galaxy. *Roy. Soc. Canada, Trans., 3rd Ser.*, v. 55, Sec. III, pp. 1–14.
- *a.* Photos.
- *b.* Clusters mentioned.

1961*III* Sawyer Hogg, H. Report of Sub-commission 27b, Variable stars in star clusters. *I. A. U. Trans.*, v. XI A, pp. 271–279.

1961 Sharov, A. S., and Pavlovskaya, E. D. On the kinematics of the globular clusters. *A. J. UdSSR*, v. 38, pp. 939–945; *Soviet Astronomy AJ*, v. 5, pp. 716–721, 1962.

1961 Slettebak, A., Bahner, K., and Stock, J. Spectra and colors of early-type stars near the north galactic pole. *Ap. J.*, v. 134, pp. 195–206. Page 205, Spectra in globular clusters by G. Münch.

1961 Stothers, R. B., and Schwarzschild, M. On the periods of long-period variables in globular clusters. *Ap. J.*, v. 133, pp. 343–346.

1961 Woolley, R. v. d. R. Globular clusters. *Obs.*, v. 81, no. 924, pp. 161–182.

1961*I* Woolley, R. v. d. R., and Dickens, R. J. Studies in the equilibrium of globular clusters. IV. Surface photometry compared with theory. *Roy. Obs. Bull.*, no. 42, pp. 291–300.

1961*II* Woolley, R. v. d. R., and Dickens, R. J. Studies in the equilibrium of globular clusters. V. Rotation. *Roy. Obs. Bull.*, no. 46, pp. 377–386.

1962 Aller, L. H. Spectrophotometry of southern objects. *A. S. P. Pub.*, v. 73, p. 398.

1962 Alter, G., Hogg, H. S., Ruprecht, J. Catalogue of star clusters and associations, Supplement 4. *Astr. Inst. Czechoslovakia, Bull.*, v. 13, no. 1, App., pp. 28.

1962*I* Arp, H. The effect of reddening on the derived ages of globular clusters and the absolute magnitudes of RR Lyrae cepheids. *Ap. J.*, v. 135, pp. 971–975.

1962*II* Arp, H. C. Intrinsic variables and stellar evolution. Symposium on Stellar Evolution, Nov. 7–11, 1960. *Ast. Obs. Univ. La Plata*, pp. 87–117.
a. Page 90. Regions of variability.
b. Page 91. Long period variables in globular clusters.
c. Page 93. The RR Lyrae stars.
d. Page 94. The long period globular cluster Cepheids.
e. Pages 107–117. Discussion.

1962 Bahner, K., Hiltner, W. A., and Kraft, R. P. Colors and magnitudes for 45 Cepheids of the northern Milky Way. *Ap. J. Supp.*, v. VI, no. 59, pp. 319–356.

1962 van den Bergh, S. The color-magnitude diagram of high-velocity stars. *A. S. P. Pub.*, v. 74, pp. 308–311.

1962 van den Bergh, S., and Henry, R. C. Photoelectric spectrophotometry of globular clusters. *Dunlap Pub.*, v. 2, no. 10, pp. 281–313.

1962 Eggen, O. J., and Sandage, A. R. On the existence of subdwarfs in the (M_{bol}, log T_e)–Plane. II. *Ap. J.*, v. 136, pp. 735–747.

1962 Fernie, J. D. Distance to the galactic center from globular clusters. *A. J.*, v. 67, no. 10, pp. 769–774. Table of X, Y, Z for 74 clusters.

1962 Haffner, H. Report of meetings of I. A. U. Commission 37, Star Clusters and Associations. *I. A. U. Trans.*, v. XI B, pp. 341–346.

1962 King, I. The structure of star clusters. I. An empirical density law. *A. J.*, v. 67, no. 8, pp. 471–485.

1962 Kinman, T. D. Limiting radii of stellar systems in the neighborhood of the galaxy. *A. S. P. Pub.*, v. 74, pp. 424–429; *Lick Cont.*, no. 138.

1962 Kumar, S. S. On the age of the galaxy. *Obs.*, v. 82, no. 926, pp. 34–36.

1962 MICHIE, R. W. Dynamics of spherical stellar systems: properties of theoretical models, and comparison with clusters and elliptical galaxies. *A. J.*, v. 67, no. 9, p. 582.

1962*I* ROSINO, L. Work being carried out at the Asiago Observatory. *I. A. U. Trans.*, v. XI B, pp. 300–301.

1962*II* ROSINO, L. Ricerche astronomiche nell' emisfero australe III. Stelle variabili negli ammassi globulari NGC 5986, 6304, 6558, 6569, 6637 (M 69), 6681 (M 70) e zone attigue. *Soc. Astr. Ital. Mem.*, v. XXXIII no. 4; *Asiago Cont.* no. 132. Table 14. Morgan's spectral classes and numbers of variables.

1962 ROSINO, L., and SAWYER HOGG, H. Report of meeting of Sub-Commission 27b, Variable stars in star clusters, 22 August 1961. *I. A. U. Trans.*, v. XI B, pp. 301–302.

1962*I* SANDAGE, A. Introductory report. Symposium on Stellar Evolution, Nov. 7–11, 1960. *Ast. Obs. Univ. La Plata*, pp. 1–22.

1962*II* SANDAGE, A. The age of the oldest stars in the galaxy compared with the cosmic expansion time. Symposium on Stellar Evolution, Nov. 7–11, 1960. *Ast. Obs. Univ. La Plata*, pp. 119–135.

1962 SAWYER HOGG, H. Numbers and kinds of variables in globular clusters. *Remeis-Sternw. Bamberg, Kl. Veröff.*, no. 34, pp. 8–10.

1962 STRUVE, O. The oldest star clusters. *Sky and Tel.*, v. 24, pp. 261–263.

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BY HARRY H. GUETTER

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DISTANCES OF 97 OB STARS

By Harry H. Guetter*

Abstract

Equivalent widths of the Hγ line are determined for 97 stars of spectral range B3 and earlier which have been observed spectroscopically at the David Dunlap Observatory. All the equivalent widths were reduced to the system of the Dominion Astrophysical Observatory, Victoria, B.C. The distances of these stars were obtained by the use of the Hγ-M_V calibration determined by Johnson and Iriarte (1958) and the assumption that the ratio of total to selective absorption is 3.0.

The distances of various association members are compared to one another, and it is concluded that the luminosity calibration may be incorrect for very bright stars.

Finally, the effect of duplicity among OB stars on the Hγ-M_V calibration is briefly examined.

Introduction

The basis of this study is the correlation between the equivalent width of the Hγ line of an early-type stellar spectrum and the star's absolute magnitude, to which attention has been directed by Petrie (1953). This relation has been recalibrated by Johnson and Iriarte (1958) with cluster stars whose luminosities have been determined by zero-age main sequence fits. By a combination of this estimate of absolute magnitude with the apparent magnitude and colour of the star, the distance of the star can be computed.

Observational Data

Stars of spectral type no later than B3 and fainter than apparent magnitude 6.0 were considered in this investigation. With these criteria 97 stars were selected from spectrograms already available in the plate files of the David Dunlap Observatory. Upwards to eight usable spectrograms were available for each star.

The spectrograms had all been obtained on Eastman 103aO emulsion with the one-prism spectrograph of the 74-inch telescope at the David Dunlap Observatory. The spectrograph has two cameras giving dispersions at Hγ of 33 A./mm. and 66 A./mm. respectively. The former was used for many stars brighter than $m_{pg} = 7.0$, while the latter was used to obtain fainter spectra. The slit width was chosen between 0.02 mm. and 0.04 mm., depending on the brightness of the star and the seeing and transparency during the time of observation.

*Now at the U.S. Naval Observatory, Flagstaff, Arizona.

Calibration and Error Determination

The measurement of the spectra was carried out with the Dunlap microphotometer (Oke 1957) with the aid of tube sensitometer calibrations. The sensitometer spots, exposed on each plate beforehand, are used to transform density to intensity. The intensity steps were taken from the work of Armstrong (1933), checked by Wellmann (1957).

The mechanical magnification of the microphotometer was calculated from the iron arc comparison lines to be 45.5.

The spectra usually were traced from λ4250 to λ4450 centred about Hγ so that the continuum could be estimated fairly accurately. The mean of density readings taken on the unexposed parts of the plate adjacent to the Hγ line was considered to be zero intensity since many plates showed uneven fog density.

To obtain the line profile, the best-determined side of the Hγ line was drawn, the centre of the profile estimated, and the opposite side of the profile drawn symmetrically to the first. In this way the effects are minimized of other lines which are close to the Hγ line, for example OII λ4349 and λ4351, and also photographic irregularities.

The plates were given weights from zero to unity to denote the quality of the spectrogram. Similarly, the tracings were also given weights from zero to unity. The two weights were then multiplied to give the final weight for a particular measurement. In case of more than one measurement, the square of the final weight was taken to equal the sum of the squares of the individual weights. The weights of spectra obtained with the 33 A./mm. dispersion were doubled with respect to those of the 66 A./mm. dispersion.

Calibration of the Equivalent Widths

The Hγ-M_V calibration by Johnson and Iriarte (1958) is based on Victoria equivalent widths. It was therefore necessary to determine the transformation required to convert the Dunlap equivalent widths to the Victoria system. From twenty-one stars in common, it was found for the 33 A./mm. dispersion that

$$H\gamma_{\text{Victoria}} = (1.08 \pm 0.07)\, H\gamma_{\text{Dunlap}}.$$

From twenty-five stars in common, it was found for the 66 A./mm. dispersion that

$$H\gamma_{\text{Victoria}} = (1.07 \pm 0.08)\, H\gamma_{\text{Dunlap}}.$$

The individual points are shown in figures 1 and 2.

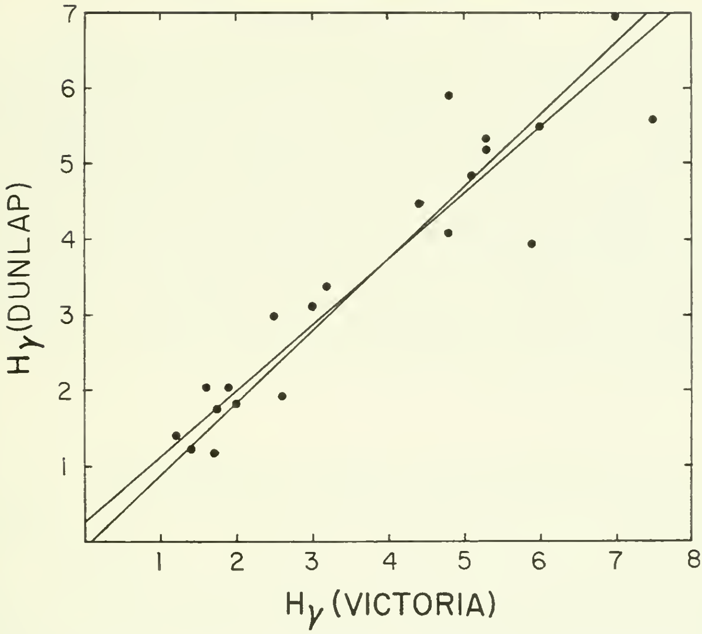

FIG. 1—Comparison of the Hγ equivalent widths from spectra obtained at the David Dunlap Observatory and the Dominion Astrophysical Observatory (Victoria) for the 33 A./mm. dispersion.

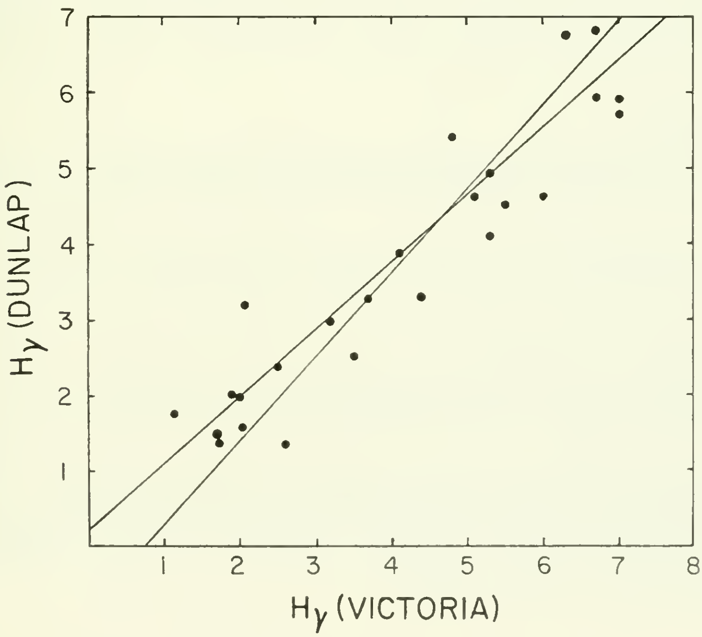

FIG. 2—Comparison of the Hγ equivalent widths from spectra obtained at the Dunlap Observatory and Victoria for the 66 A./mm. dispersion.

Absolute Magnitudes

The data for the stars which were studied in the present programme are listed in Table I. The designations of the columns are self-explanatory except for the following. Column 8 (Ref.), is the reference to the source of the photometric data: (a) Hiltner (1956), (b) Hiltner and Johnson (1956), (c) Hiltner and Iriarte (1955), (d) Author's observations obtained with the photometer attached to the 19-inch reflector at the David Dunlap Observatory (Marlborough 1964); column 9 (W), is the equivalent width of the Hγ line; column 10(Wt.), is the combined weights of the plate-tracing combination; column 11 ($\pm\Delta W$), is the standard error of the equivalent width in units of 0.01 A.

Distances of Various Associations

Some of the stars in the present programme are members of associations. Since most associations are fairly rich in early-type stars, only a few stars in each association were studied spectroscopically.

The information obtained for four associations is given in Table II. First the name of the association and its distance (as determined by other workers) are given. For each association, the individual stars are listed as to: the spectral type; the equivalent width of the Hγ line; the total weight given to the spectrum-tracing combination; the number of plates used; the internal dispersion or standard error of the equivalent width in milliangstroms; the distance modulus; and the distance in kiloparsecs.

Table II shows that the four stars of III Cygni agree fairly well with one another, giving an average distance of 1.6 kpc., which is only a little smaller than the distance given by Schmidt (1958). The three stars of III Cephei yield an average distance of 0.85 kpc., corresponding closely to that estimated by Blaauw, Hiltner and Johnson (1959). For the other two associations significant discrepancies are found, in that the computed distances of the three stars with equivalent widths smaller than about 2.0 angstroms are much greater than those with larger equivalent widths. Three possible explanations suggest themselves: (a) that the Johnson and Iriarte calibration is over-luminous for small equivalent widths, (b) that the three discordant stars are not association members, but background stars and (c) that incipient emission at Hγ in the spectra of these stars has reduced the value of the equivalent widths. It is not possible to choose among these explanations because of the small sampling.

TABLE I

DATA FOR THE OB STARS

B.D. or H.D.	l^{II}	b^{II}	Sp.	V	B−V	U—B	Ref.	W (A.)	Wt.	ΔW (0.01A.)	Dist. (kpc.)
+ 61° 39	119°.3	−0°.2	B0.5V	8.52	+0.30	−0.75	a	2.0	0.9	3	3.60
+ 61° 40	119.3	− 0.2	B2pI–II	9.55	+0.47	−0.51	a	2.3	1.4	20	4.32
3264	120.3	−14.2	B2V	7.50	−0.05	−0.63	d	9.2	1.8	35	0.20
4694	122.8	+ 1.7	B3Ia	8.50	+0.72	−0.16	a	2.8	1.0	10	1.72
5551	123.7	+ 0.9	B1.5Ib	7.71	+0.62	−0.36	a	2.0	0.7	13	1.85
13841	134.4	− 3.9	B2Ib	7.37	+0.23	−0.65	a	3.9	1.1	23	1.20
14302	135.1	− 4.4	B1II–III	8.57	+0.26	−0.56	a	3.9	1.4	36	1.69
20134	140.2	+ 2.2	B3V	7.46	+0.14	−0.51	d	7.9	1.0	3	0.23
21483	158.9	−21.3	B3III	7.03	+0.35	−0.33	a	4.7	0.9	19	0.51
1502 #3*	143.7	+ 7.6	B3III	9.30	+0.49	−0.28	d	5.3	1.2	85	0.88
1502 #4*	143.7	+ 7.7	B3III	9.43	+0.45	−0.38	d	5.1	1.5	35	1.14
35633	173.2	− 0.2	B0.5IV	8.04	+0.32	−0.66	a	2.3	1.1	18	2.33
35921	172.8	+ 0.6	O9.5III	6.81	+0.20	−0.78	a	2.8	1.0	8	1.15
43818	188.5	+ 3.9	B0II	6.92	+0.29	−0.69	a	2.0	0.8	20	1.70
57682	224.4	+ 2.6	O9V	6.44	−0.19	−1.04	b	2.3	1.2	23	2.17
149363	9.8	+26.7	B0.5III	7.81	+0.05	−0.80	d	2.2	1.2	10	3.19
161961	23.6	+13.1	B0.5III	7.89	+0.23	−0.67	d	2.3	1.3	16	2.47
166628	11.3	− 0.5	B3Ia	7.17	+0.59	−0.29	a	2.9	0.7		1.07
167263	10.8	− 1.6	O9II	5.98	+0.04	−0.88	a	2.3	0.9		1.28
168021	12.7	− 1.5	B0Ib	6.82	+0.30	−0.66	d	1.3	0.9		3.10
−13° 4930	17.0	+ 0.8	O9.5V	9.44	+0.30	−0.70	a	4.5	0.8	15	1.54
168161	18.6	+ 1.3	O8IV	9.54	+0.68	−0.42	a	1.8	0.6		3.75
168894	16.7	− 0.4	B1II	9.38	+0.64	−0.39	a	1.5	0.6		5.10

*NGC 1502, third and fourth stars listed in appendix of *Publ. U.S. Naval Obs.*, vol. 17, part 7, p. 510, 1961.

TABLE I (*continued*)

B.D. or H.D.	l^{II}	b^{II}	Sp.	V	B−V	U−B	Ref.	W (A.)	Wt.	ΔW (0.01A.)	Dist. (kpc.)
170177	18.3	− 1.2	B0.5Ia	9.44	+0.80	−0.34	c	2.6	0.9	40	2.13
171012	14.5	− 4.4	B0.5Ia	6.82	+0.45	−0.57	d	1.4	1.2	15	2.37
172028	31.0	+ 2.8	B3II	7.83	+0.55	−0.26	d	4.2	1.3	41	0.81
173637	25.3	− 2.5	B1V	9.35	+0.28	−0.66	c	2.4	0.6		4.23
173783	24.2	− 3.4	O9I	9.31	+0.51	−0.52	b	2.3	0.7	26	3.22
173987	26.9	− 2.3	B0.5Ia	8.92	+0.36	−0.64	c	2.0	1.1	4	4.45
175514	41.7	+ 3.4	O8:Vnn	8.59	+0.59	−0.45	a	4.2	0.6		0.83
+28° 3434	64.3	+ 3.2	B1Ibp	8.50	+0.20	−0.71	a	2.6	1.0	10	3.25
+28° 3438	64.2	+ 2.9	B2IV	8.93	+0.01	−0.70	a	5.3	1.5	26	1.31
186841	60.4	− 0.3	B1Ia	7.85	+0.79	−0.29	a	2.3	1.2	14	1.28
+27° 3512	64.1	+ 1.7	O7.5	8.77	+0.20	−0.78	a	2.6	1.3	35	3.03
+28° 3485	64.8	+ 1.6	B2V:n	9.40	+0.10	−0.57	a	5.6	1.5	13	1.25
188439	77.4	+ 7.8	B0.5II	6.30	−0.10	−0.86	d	4.5	0.8		0.67
+25° 4083	64.4	− 2.6	B1III	8.94	+0.63	−0.31	a	4.5	0.7		0.82
+31° 3921	69.4	+ 0.5	B1Ib	8.70	+0.46	−0.45	a	2.6	1.0	24	2.49
+35° 3956	72.6	+ 2.0	B0.5V	8.85	+0.19	−0.62	a	5.7	1.5	52	0.74
227704	72.0	+ 1.5	B0III	8.60	+0.34	−0.63	a	4.0	0.9	4	1.37
193536	82.8	+ 5.8	B2V	6.46	−0.09	−0.66	d	5.2	0.9	75	0.50
193855	77.0	+ 1.4	B2III	7.78	+0.27	−0.42	d	5.5	1.6	37	0.49
229227	76.9	+ 0.6	B0II	9.38	+0.80	−0.15	a	3.1	0.8	35	1.45
229234	76.9	+ 0.6	O9.5III	8.92	+0.77	−0.19	a	2.4	1.1	8	1.67
229238	76.9	+ 0.6	B0Ib	8.88	+0.90	−0.06	a	2.3	0.9	15	1.68
229239	76.9	+ 0.6	B1Iab	8.92	+0.87	−0.15	a	2.5	1.0	60	1.64
+45° 3230	84.5	+ 3.1	B0III	9.40	+0.75	−0.27	a	2.6	0.8	10	1.95
+45° 3246	84.8	+ 2.2	B1Vn	9.67	+0.17	−0.64	a	5.3	1.0	62	1.37

TABLE I (*continued*)

B.D. or H.D.	l^{II}	b^{II}	Sp.	V	B−V	U−B	Ref.	W (A.)	Wt.	ΔW (0.01A.)	Dist. (kpc.)
199140	72.8	−10.5	B2III	6.52	−0.12	−0.80	d	4.7	1.5	33	0.71
+45° 3339	86.8	+ 0.6	B1IV	9.93	+0.42	−0.42	a	5.2	1.0	27	1.14
201345	78.5	− 9.5	B0IV	7.66	−0.13	−0.95	d	3.3	1.2	23	2.14
202349	82.5	− 7.5	B0.5V	7.37	−0.20	−0.95	d	5.2	1.0	67	0.81
239767	99.7	+ 2.7	B0.5V:p	9.25	+0.70	−0.35	a	4.4	0.9	22	0.92
235618	98.7	+ 1.4	B1IV	9.66	+0.68	−0.31	a	3.4	1.1	44	1.85
207563	75.4	−25.1	B3V	6.31	−0.10	−0.64	d	6.0	0.9		0.36
235673	98.4	− 1.6	O7	9.14	+0.21	−0.77	a	3.0	1.3	26	2.95
209008	65.9	−36.5	B3V	5.97	−0.04	−0.50	d	5.7	0.9		0.33
+53° 2790	100.6	− 1.1	O9.5III	9.86	+0.25	−0.71	a	2.8	1.0	15	4.38
210809	99.9	− 3.1	O9.5III	7.54	+0.05	−0.89	a	2.1	1.2	8	3.01
+53° 2820	101.3	− 1.7	B0IV:n	9.95	+0.10	−0.78	a	3.4	0.7		4.47
+54° 2718	102.0	− 0.9	B2III	10.15	+0.19	−0.62	a	4.2	0.6		3.40
+54° 2726	102.2	− 1.0	B1II	9.38	+0.33	−0.54	a	3.1	0.9	29	2.98
235783	101.6	− 1.9	B1Ib	8.68	+0.17	−0.71	a	3.4	1.0	9	2.67
+53° 2843	101.7	− 2.2	O8	9.50	+0.21	−0.75	a	1.8	0.8	2	7.05
+60° 2380	105.4	+ 3.2	B2III	9.04	+0.39	−0.50	a	2.9	1.0	48	2.69
239923	104.4	+ 1.6	B3Ib	8.89	+0.83	−0.12	a	1.7	0.8	26	3.37
235807	102.7	− 1.3	B0.5IVn	9.56	+0.21	−0.67	a	2.7	0.8	3	4.34
235813	102.3	− 2.0	B0III	8.84	+0.22	−0.74	a	1.8	0.9	2	5.20
T.B. 5–21†	103.0	− 1.3	O5	10.29	+0.27	−0.73	a	2.9	0.4		4.83
235825	102.9	− 1.7	O9V	9.28	+0.24	−0.73	a	2.2	0.4		4.63
+54° 2761	103.2	− 1.4	O5f	9.98	+0.34	−0.68	a	2.3	1.0	11	5.25
+54° 2764	103.0	− 1.6	B1Ib	9.54	+0.28	−0.62	a	3.1	0.6		3.73

†*Boletin de los Observatorios Tonantzintla y Tacubaya*, no. 5.

TABLE I (*continued*)

B.D. or H.D.	l^{II}	b^{II}	Sp.	V	B—V	U—B	Ref.	W (A.)	Wt.	ΔW (0.01A.	Dist. (kpc.)
+55° 2748	103.7	− 1.0	B0.5V	9.96	+0.44	−0.52	a	2.9	0.8	2	3.47
+60° 2405	107.1	+ 3.2	B3nnV	9.91	+0.54	−0.19	a	6.4	0.6		0.69
+55° 2770p	104.8	− 1.4	B1II	10.10	+0.37	−0.54	a	6.6	0.5		0.75
+55° 2770f	104.8	− 1.4	B1.5III	9.70	+0.35	−0.54	a	5.2	0.7		1.15
+55° 2771	105.0	− 1.3	B1IV	9.70	+0.48	−0.45	a	3.0	0.7		2.86
214240	101.8	− 7.2	B3V	6.30	−0.06	−0.53	d	5.8	0.8		0.38
214652	96.1	−17.8	B3V	6.81	−0.15	−0.71	d	6.6	1.4	23	0.39
240068	107.3	− 0.5	B0III	9.64	+0.49	−0.52	a	4.4	0.6		1.43
216658	109.7	+ 2.3	B0V	8.89	+0.70	−0.29	a	4.6	1.5	21	0.66
216711	109.9	+ 2.7	B1V	9.05	+0.62	−0.33	a	4.7	1.4	13	0.76
218407	104.8	+13.0	B3IV	6.62	−0.02	−0.71	d	5.2	0.9		0.54
218941	110.9	+ 0.1	B1.5II	9.71	+0.83	−0.20	a	1.4	0.4		5.08
+61° 2408	111.9	+ 1.2	B0III?p?	9.7	+0.79	−0.21	a	2.6	0.5		2.1
+63° 1962	112.8	+ 2.8	B1III	8.40	+0.32	−0.56	a	4.3	1.5	42	1.13
+63° 1964	112.9	+ 3.1	B0II	8.46	+0.71	−0.38	a	1.5	1.5	13	2.83
+60° 2553	113.2	+ 0.0	B2II	10.08	+0.45	−0.43	a	4.1	1.0	73	2.59
T.B. 5–36†	114.9	− 0.3	B0.5IV	9.78	+0.53	−0.45	a	3.6	0.7	17	2.14
+61° 2509	115.1	+ 0.3	B0.5Ib	8.42	+0.46	−0.55	a	2.5	1.1	30	2.23
+60° 2615	115.1	− 0.1	B0.5Ib	9.10	+0.60	−0.45	a	1.9	1.1	13	3.63
+61° 2515	115.4	+ 0.4	B0.5V	9.95	+0.43	−0.51	a	4.6	0.9	40	1.60
+61° 2526	115.5	+ 0.1	B2Ib	8.77	+0.39	−0.50	a	3.4	1.1	2	2.21
+61° 2529	115.5	+ 0.1	B1Ib	8.65	+0.53	−0.47	a	2.7	1.2	22	2.11
+61° 2550	116.1	+ 0.0	B0IV	9.29	+0.33	−0.63	a	2.7	1.1	16	3.16
+61° 2559	116.3	+ 0.3	O9V	9.72	+0.29	−0.66	a	3.4	1.2	11	3.05
T.B. 5–39†	116.6	− 1.1	B1V	10.22	+0.29	−0.59	a	6.0	0.9	21	1.08

†*Boletin de los Observatarios Tonantzinlla y Tacubaya*, no. 5.

TABLE II

DISTANCES OF VARIOUS ASSOCIATIONS BY MEANS OF INDIVIDUAL STELLAR DISTANCES

Star Number	Spectral Type	W	wt.	n	ΔW	$m_0 - M$	Distance (kpc.)
III CYGNI, distance = 1.93 kpc. (Schmidt 1958)							
H.D.E. 229227	B0II	3.1	0.8	2	35	10.8	1.45
H.D.E. 229234	O9.5III	2.4	1.1	3	8	11.1	1.67
H.D.E. 229238	B0Ib	2.3	0.9	3	15	11.1	1.68
H.D.E. 229239	B1Iab	2.5	1.0	3	60	11.1	1.64
II CEPHEI, distance = 3.9 kpc. (Schmidt 1958)							
H.D.E. 235673	O7	3.0	1.3	3	26	12.4	2.95
B.D. +54°2726	B1II	3.1	0.9	3	29	12.4	2.98
H.D.E. 235783	B1Ib	3.4	1.0	3	9	12.1	2.67
B.D. +53°2843	O8	1.8	0.8	2	2	14.2	7.05
H.D.E. 235813	B0III	1.8	0.9	2	2	13.6	5.20
H.D.E. 235825	O9V	2.2	0.4	1		13.3	4.63
B.D. +54°2764	B1Ib	3.1	0.6	1		12.9	3.73
III CEPHEI, distance = 0.725 kpc. (Blaauw, Hiltner, and Johnson 1959)							
H.D. 216658	B0V	4.6	1.5	5	21	9.1	0.66
H.D. 216711	B1V	4.7	1.4	4	13	9.4	0.76
B.D. +63°1962	B1III	4.3	1.5	5	42	10.3	1.13
I CASSIOPEIAE, distance = 2.5 kpc. (Morgan, Code and Whitford 1953)							
B.D. +61°2509	B0.5Ib	2.5	1.1	3	30	11.7	2.23
B.D. +60°2615	B0.5Ib	1.9	1.1	4	13	12.8	3.63
B.D. +61°2526	B2Ib	3.4	1.1	3	2	11.7	2.21
B.D. +61°2529	B1Ib	2.7	1.2	3	22	11.6	2.11
B.D. +61°2550	B0IV	2.7	1.1	3	16	12.5	3.16
B.D. +61°2559	O9V	3.4	1.2	3	11	12.4	3.05

CONCLUSIONS

The conclusions reached in this paper are only tentative. The derived distances may be incorrect for the following reasons: First, the spectra of some stars may have at Hγ a little emission which is difficult to distinguish on the tracings from the grain of the photographic emulsion. This would cause the equivalent width to be under-estimated and the distances obtained would be too large. Secondly, there is the fact that according to Blaauw and van Albada (1963) approximately half the stars of the nearest associations are spectroscopic binaries.

Heard (private communication), in a study of five stars in the association III Cephei, found one definite, and three probable spectroscopic binaries. It may be shown that in the present method of determining absolute magnitude, the effect of an unresolved binary is to lead to an absolute magnitude which is intermediate between the absolute magnitudes of the two components. The distance of such a binary is therefore underestimated.

However, due to the high incidence of spectroscopic binaries among OB stars and the relative frequency of line emission, it seems doubtful that the stars used for their calibration by Johnson and Iriarte were all single stars without any $H\gamma$ emission. Hence the $H\gamma$-M_V relation is probably overluminous where derived from single stars, and underluminous where derived from binaries. Therefore, by assuming that the sample of stars used in this paper is similar to those used by Johnson and Iriarte, one would expect that on the average their calibration is valid for use in this study. This statistical conclusion, however, may be invalid for the most luminous stars because of the small number of such objects.

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References

Armstrong, W. S. 1933, M.A. Thesis, University of Toronto.
Blaauw, A., Hiltner, W. A., Johnson, H. L. 1959, *Ap. J.*, vol. 130, p. 69.
Blaauw, A., and Albada, T. S. 1963, *Ap. J.*, vol. 137, p. 791.
Hiltner, W. A. 1956, *Ap. J. Suppl.* vol. 2, p. 389.
Hiltner, W. A., and Iriarte, B. 1955, *Ap. J.*, vol. 122, p. 185.
Hiltner, W. A., and Johnson, H. L. 1956, *Ap. J.*, vol. 124, p. 367.
Johnson, H. L., and Iriarte, B. 1958, *Low. Obs. Bull.*, vol. 4, p. 47.
Marlborough, J. M. 1964, *A. J.*, vol. 69, p. 215.
Morgan, W. W., Code, A. D. and Whitford, A. E. 1953, *Ap. J.*, vol. 118, p. 318.
Oke, J. B. 1957, *R.A.S.C. Journal*, vol. 51, p. 133.
Petrie, R. M. 1953, *Publ. D.A.O.* vol. 9, p. 251.
Schmidt, K. H. 1958, *A. N.*, vol. 284, p. 76.
Wellmann, P. 1957, *Ap. J.*, vol. 126, p. 30.

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SPECTROGRAPHIC ORBITS OF THE ECLIPSING SYSTEMS V822 AQUILAE, BV 241, BV 342, BV 374

PIM FITZGERALD

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SPECTROGRAPHIC ORBITS OF THE ECLIPSING SYSTEMS V 822 AQUILAE, BV 241, BV 342, BV 374

By Pim FitzGerald

These four eclipsing systems have been studied spectrographically at this observatory in the years 1962 and 1963. Earlier observations of the star V 822 Aquilae, made between the years 1936 and 1939, have also been employed in the spectrographic study of this star.

Photometric studies made of V 822 Aquilae by Nicolini at Naples, and of the other three systems by the observers at Bamberg, had identified the stars as eclipsing systems. Periods were established by these observers, though not the other photometric elements.

The secondary component is visible in each spectrum, but it is too weak for accurate estimation of the mass-ratio except in the case of BV 241. Some indication of the mass-ratio is given with the spectrographic elements of each. The spectra of each system have been classified according to the MK system.

V 822 Aquilae

The star V 822 Aquilae, H.D. 183794, $\alpha(1900)$ 19^{h} $26^{\mathrm{m}}.0$, $\delta(1900)$ $-02°$ $19'$, m_{pg} 6.7—7.3, sp. B8V, had been observed spectroscopically at this observatory by the late F. S. Hogg between 1936 and 1939.

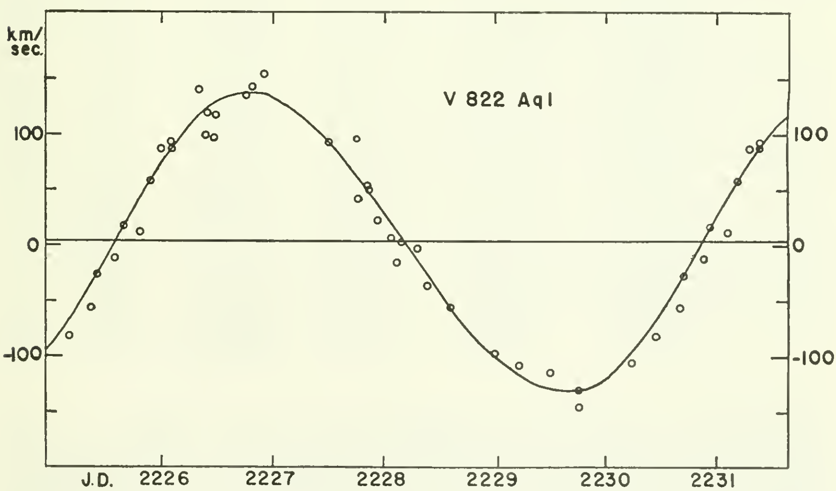

Figure 1

TABLE I

RADIAL VELOCITY OBSERVATIONS OF V 822 AQUILAE

J.D.	V_o km./sec.	$V_o - V_c$ km./sec.	Phase from final T	Dispersion A./mm.
2428272.676	− 14.6	−23.9	2.187	33
282.874	+ 96.2	+34.0	1.795	33
296.832	+ 12.0	−22.1	5.369	33
310.850	−108.2	+ 7.0	3.294	66
311.866	−105.2	− 1.1	4.310	66
314.673	+ 53.8	− 4.7	1.917	66
317.800	− 11.8	− 5.7	4.951	66
323.846	+140.5	+24.2	0.408	66
325.816	− 2.2	+14.2	2.378	66
328.800	+ 87.7	+18.3	0.063	66
355.693	+119.3	− 4.2	0.482	66
362.641	+ 7.0	− 9.4	2.134	66
400.639	− 96.7	+ 0.4	2.071	66
407.608	− 56.2	−12.2	4.744	66
800.544	+ 97.1	−31.2	0.545	66
2429165.514	+ 93.4	+ 9.8	0.154	66
176.507	+117.8	−11.2	0.561	66
183.494	+ 3.3	+ 2.3	2.235	66
432.793	− 55.8	− 0.7	2.679	66
465.719	−129.2	+ 2.1	3.834	66
469.648	− 36.0	− 7.6	2.468	66
486.663	−114.5	+15.0	3.580	66
2437558.566	+ 99.3	−23.3	0.471	33
563.553	+ 97.4	+12.2	0.164	33
569.516	+134.5	− 3.8	4.522	33
570.535	+ 41.8	−13.2	1.853	33
572.534	−145.5	−14.6	3.839	33
816.778	− 82.6	− 3.8	4.522	33
823.838	+154.7	+18.9	0.990	33
824.785	+ 50.7	+ 7.1	1.938	33
840.750	+ 23.3	− 9.5	2.017	33
843.749	+ 16.8	+10.8	5.014	33
864.694	+ 26.6	+10.9	4.781	33
891.653	+ 57.3	+ 4.9	1.075	33
892.579	+142.9	+ 4.9	0.895	33
898.565	+ 92.9	+ 4.8	1.583	33

Observation was recommenced in 1962 by J. F. Heard as a result of the photoelectric observations of Nicolini (Fresa 1961), which identified the star as an eclipsing system of period 2.6477 days. A total of thirty-six measurable plates have been used to determine the spectrographic

TABLE II

ORBITAL ELEMENTS OF V 822 AQUILAE

Element	Preliminary	Final	m.e.
Period	P 5.2949 days	5.29510	0.00004
Eccentricity	e 0.0	0.089	0.028
Angle of periastron	ω	294°	19°
Epoch of mean longitude	T_o J.D. 2432227.020	J.D. 2432226.900	0.022
Epoch of periastron	T	J.D. 2432225.924	0.279
Velocity of the system	γ +4.0 km./sec.	−1.6	2.7
Semi-amplitude	K 138.0 km./sec.	135.0	4.1
$a \sin i$		9.8×10^6 km.	0.4×10^6
Mass-ratio		1.0:	0.1:
m $\sin^3$ i		5: ☉	2:

orbit. The spectral lines are broad, and on most plates only the lines of hydrogen and sometimes λ4481 of Mg II are measurable. Lines of the secondary spectrum appear on a few plates, but ought only to be used to give a rough indication of the mass-ratio, since they are very weak and indistinct.

Since the spectrographic observations cover a long interval (between 1936 and 1963), the period determined by Nicolini has not been used in the solution. The period obtained here, 5.29510 days, is close to double that of Nicolini. This may be explained by his observing primary and secondary minima of equal depth, and by his making the reasonable assumption that he had observed only one of two eclipses.

The six elements were obtained from the pre-computed curves of R. K. Young (1936), and then corrected by a computer programme of least squares employing the method of Sterne (1941) for zero eccentricity. The mass-ratio was estimated from the method of Wilson (1941). The velocity of the interstellar medium, determined from the Ca II lines λ3933 and λ3968, was found to be -9.8 ± 1.0 km./sec.

Table I lists the observed velocities and velocity residuals; Table II lists the preliminary and final elements; and figure 1 shows the velocity curve of the system. The average internal probable error of a single velocity determination is about 5 km./sec.

BV 241

The star BV 241, H.D. 190020, $\alpha(1900)$ 19^h $57^m\!.9$, $\delta(1900)$ 73° 21′, m_{pg} 9.4–10.3, sp. F5V, F5V, was identified as an eclipsing variable of period 1.682000 days by the Bamberg observers from photographic

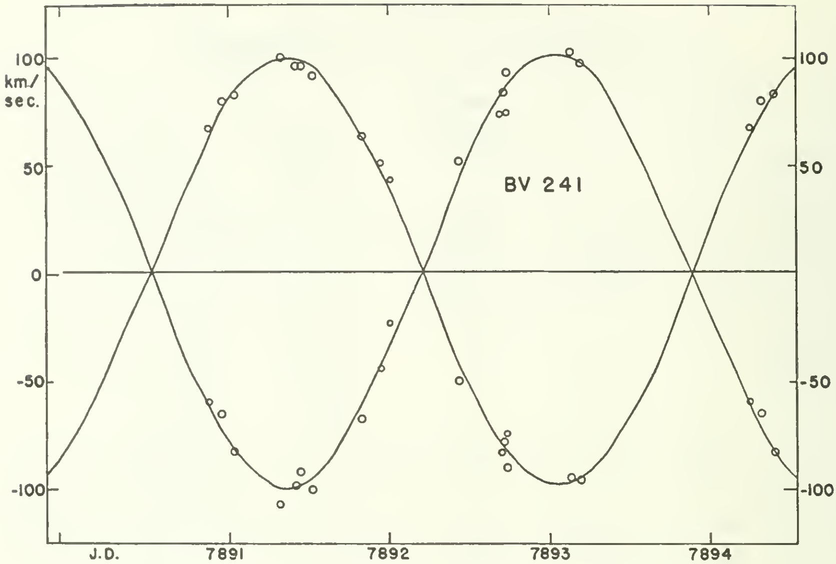

FIGURE 2

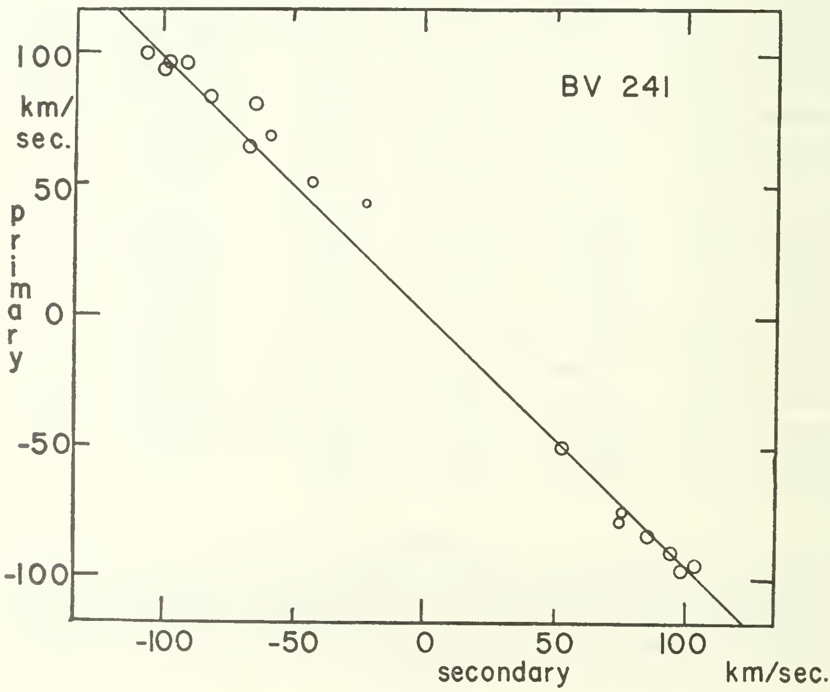

FIGURE 3

TABLE III

RADIAL VELOCITY OBSERVATIONS FOR BV 241

J.D.	Primary V_o (km./sec.)	Primary V_o-V_c (km./sec.)	Secondary V_o (km./sec.)	Secondary V_o-V_c (km./sec.)	Phase from final T_o	Weight
2437843.785	+ 68.7	+4.4	− 59.3	+ 3.0	2.870	0.7
7844.741	+ 63.7	+0.9	− 67.4	− 6.7	0.462	1.0
7847.741	+ 93.9	−2.1	− 99.6	− 5.3	0.152	1.0
7855.733	− 89.2	−6.8	+ 93.4	+ 7.6	1.362	1.0
7858.797	− 49.6	−7.5	+ 52.1	+ 7.0	1.062	1.0
7860.768	+ 83.4	−1.4	− 82.4	+ 0.6	3.033	1.0
7865.802	− 77.9	+2.2	+ 73.6	− 9.9	1.339	0.7
7879.678	− 94.7	+1.3	+102.8	+ 3.2	1.759	1.0
7884.723	+ 96.3	−3.3	− 91.7	+ 6.3	0.076	1.0
7892.702	− 82.9	−4.1	+ 84.2	− 2.0	1.327	1.0
7894.685	+100.1	−1.0	−107.1	− 7.6	3.310	1.0
7898.679	+ 51.5	+6.8	− 43.3	− 0.7	0.576	0.7
7906.647	− 95.6	−2.0	+ 97.4	+ 0.2	1.816	1.0
7911.606	+ 96.3	−4.2	− 97.7	+ 1.1	0.047	1.0
7915.559	+ 43.8	+9.4	− 23.0	+ 9.2	0.636	0.5
8161.852	− 74.0	+7.9	+ 74.5	−10.8	1.357	0.7
8166.808	+ 80.3	+5.2	− 64.9	+ 8.3	2.949	1.0

TABLE IV

ORBITAL ELEMENTS FOR BV 241

Element		Preliminary	Final	m.e.
Period	P	3.364000 days	3.364000	
Eccentricity	e	0.0	0.0	0.014
Epoch of mean longitude	T_o	J.D. 2437891.320	J.D. 2437891.375	0.025
Velocity of the system	γ	0.0 km./sec.	+1.3	1.0
Semi-amplitude, primary	K_1	100.0 km./sec.	99.4	1.7
Semi-amplitude, secondary	K_2	105.0 km./sec.	100.4	1.7
$a_1 \sin i$, primary			4.60×10^6 km.	0.08×10^6
$a_2 \sin i$, secondary			4.65×10^6 km.	0.08×10^6
Mass-ratio			1.01	0.02
$m_1 \sin^3 i$, primary			1.38 $\odot$	0.03
$m_2 \sin^3 i$, secondary			1.37 $\odot$	0.03

photometry (Strohmeier 1959). Spectrographic observation was started at this observatory in 1962. Nineteen usable plates were obtained during the summers of 1962 and 1963 using a dispersion of 33 A./mm.

Both spectra are visible and are of approximately equal strength. The number of lines in the spectrum of each component which could be measured was about fifteen on plates of normal exposure and reasonably large doublet separation, and about five on those of weak exposure or those on which the double lines were close. Weights based on the plate quality and velocity separation were assigned to the individual velocity determinations and these are given in Table III. The average internal probable error of a velocity measure from a well exposed plate is 2 km./sec., and from a weak plate is 5 km./sec.

Exactly double the period obtained from the photometric investigation has been used in the solution for the elements, since it fitted our observations well. The explanation for the difference in period is the same as that given for V 822 Aquilae. The remaining elements were obtained from the pre-computed curves of R. K. Young (1936), and then corrected by a computer programme of least squares following the method of Sterne (1941) for double-line binaries of zero eccentricity.

The mass-ratio was estimated from the ratio of semi-amplitudes and by the method of Wilson (1941). Agreement was found within the mean error for both the mass-ratio and the velocity of the system as found from each method. The mass-ratio and velocity of the system given by the least-squares solution were, respectively; 1.01 ± 0.02, and $+1.3 \pm 1.0$ km./sec., and by Wilson's method: 1.03 ± 0.02, and $+1.2 \pm 0.8$ km./sec.

Table III lists the observed velocities and velocity residuals; Table IV lists the preliminary and final elements; figure 2 shows the velocity curves of both components of the system; and figure 3 shows the diagram for Wilson's method of obtaining the mass-ratio.

BV 342

This star, BV 342, H.D. 204038, $\alpha(1900)$ 21^h $20^m\!.8$, $\delta(1900)$ 33° 16′, m_{pg} (1931–1939) 8.6–9.1, m_{pg} (1952–1960) 8.35–8.85, sp. A3Vm, was identified as an eclipsing variable of period 0.7858620 days by the Bamberg observers from photographic photometry (Strohmeier, Knigge and Ott 1962). They have pointed out that the character of the light curve and photographic magnitude of the system have changed considerably between 1931 and 1960. Twenty-seven spectrograms of the system were obtained during 1962 at this observatory using a dispersion of 33 A./mm. The mean exposure time was about 0.06 days.

The spectrum of the primary component is that of a metallic line A-star having very wide absorption lines. The classification of A3V

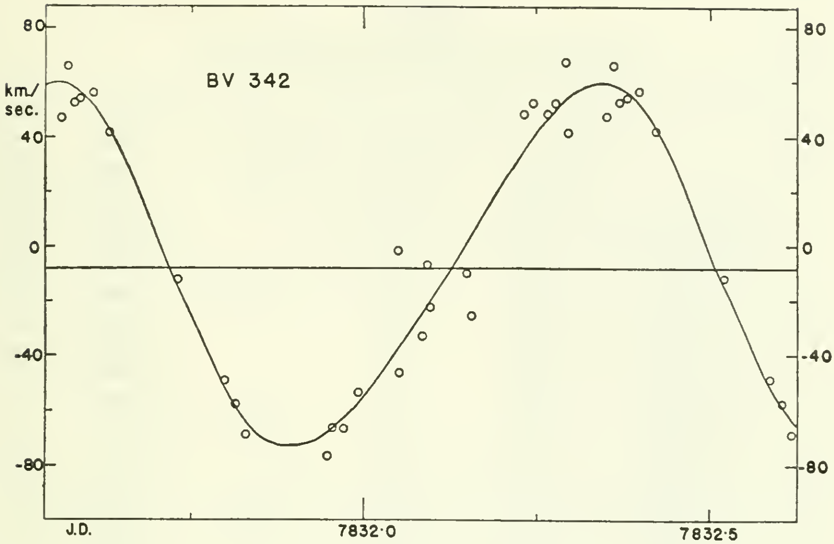

FIGURE 4

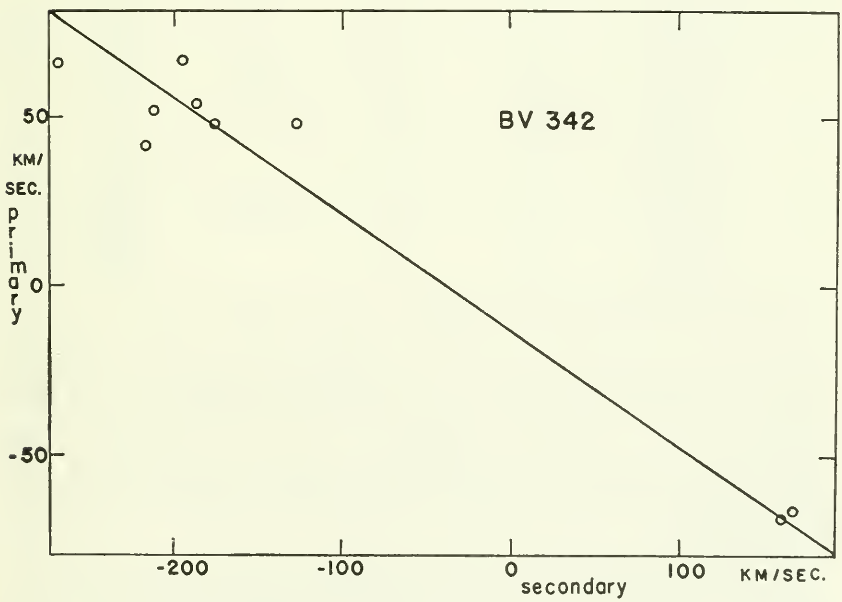

FIGURE 5

TABLE V

RADIAL VELOCITY OBSERVATIONS OF BV 342

J.D.	Primary V_o km./sec.	Primary $V_o - V_c$ km./sec.	Secondary V_o km./sec.	Phase from final T
2437831.799	−49.0	+ 3.7		0.104
840.790	− 9.5	−11.8		0.451
844.817	+52.3	+11.5	−212.2	0.549
852.782	+47.2	−12.2		0.655
855.658	−32.9	− 8.7		0.388
858.709	−53.6	+ 3.4		0.295
861.808	−76.8	− 9.4		0.251
869.674	−66.3	− 0.3	+166.9	0.258
878.760	+56.4	+ 4.1		0.700
886.043	+42.0	− 1.7		0.724
888.870	+67.1	+13.7	−195.3	0.594
891.691	−66.6	− 3.4		0.271
895.749	−22.0	− 2.7		0.400
898.613	−57.8	+ 1.1		0.120
898.888	− 6.5	− 6.5		0.395
899.847	+48.3	+ 1.3	−127.7	0.568
904.658	+66.3	+ 7.4	−269.3	0.664
906.703	− 1.8	+36.5		0.351
907.716	+52.3	+ 2.5		0.579
907.818	+54.2	− 2.5	−187.1	0.681
911.664	+41.7	−12.5	−217.0	0.597
915.669	+52.3	− 4.6		0.673
915.818	−12.0	+ 2.5		0.036
918.674	+48.5	+12.5	−175.5	0.535
938.706	−68.7	− 5.2	+160.8	0.134*
954.642	−46.4	− 8.7		0.353
955.533	−25.8	−31.2		0.458

*Secondary given only half weight.

was based on the hydrogen line strength in the spectrum. The measured line broadening of 150 km./sec. for the iron lines coincides well with the value given by Babcock (1960) for rotational broadening in an early A-star with a period of the order of 0.8 days. This indicates that the orbital and rotational periods of the primary component may be synchronized.

The spectrum of the secondary component is visible on several of the plates, but is extremely weak and diffuse, being measurable on only a few of the plates near phases of extreme velocities. Between fifteen and twenty-five lines were measured on each plate for the primary com-

TABLE VI

ORBITAL ELEMENTS FOR BV 342

Element		Preliminary	Final	m.e.
Period	P	0.7858620 days	0.7858620	
Eccentricity	e	0.21	0.115	0.053
Angle of periastron		120°	76°	34°
Epoch of periastron	T	J.D. 2437831.800	J.D. 2437831.695	0.076
Velocity of the system	γ	−4.5 km./sec.	−8.1	2.8
Semi-amplitude, primary	K_1	71.0 km./sec.	65.9	3.8
$a_1 \sin i$, primary			7.03×10^5 km.	0.43×10^5
Mass-ratio			2.95	0.12
$m_1 \sin^3 i$, primary			1.02 ⊙	0.36
$m_2 \sin^3 i$, secondary			0.35 ⊙	0.24

ponent, giving an average internal probable error for one velocity determination of 3 km./sec. On the nine plates measured for the secondary component, only the lines of hydrogen, $H\beta$ and $H\gamma$, could be measured, giving an average internal probable error of 9 km./sec. for one velocity determination.

Strohmeier's period fitted our observations well, and it was therefore used in the solution for the orbit. The remaining elements were obtained from the pre-computed curves of R. K. Young (1936), and then adjusted by a computer programme of least squares employing the method of Lehmann-Filhés (1894) for a single-line binary.

The mass-ratio has been estimated using the method of Wilson (1941). Agreement was found within the mean errors between the velocity of the system as determined from Wilson's method (-9.5 ± 1.0 km./sec.) and from the Lehmann-Filhés method (-8.1 ± 2.8 km./sec.).

Table V lists the observed radial velocities and the velocity residuals; Table VI lists the preliminary and final elements; figure 4 shows the velocity curve of the primary component; and figure 5 shows the diagram for Wilson's method of obtaining the mass-ratio.

BV 374

This star, BV 374, H.D. 217224, $\alpha(1900)$ $22^h\ 54^m.2$, $\delta(1900)$ 67° 52′, m_{pg} 8.2–8.8, sp. B3V, was found to be an eclipsing variable of period 4.908756 days by the Bamberg observers from photographic photometry (Strohmeier, Knigge and Ott 1962). Nineteen usable spectrograms have been obtained at this observatory in the summer of 1962 with a dispersion of 33 A./mm.

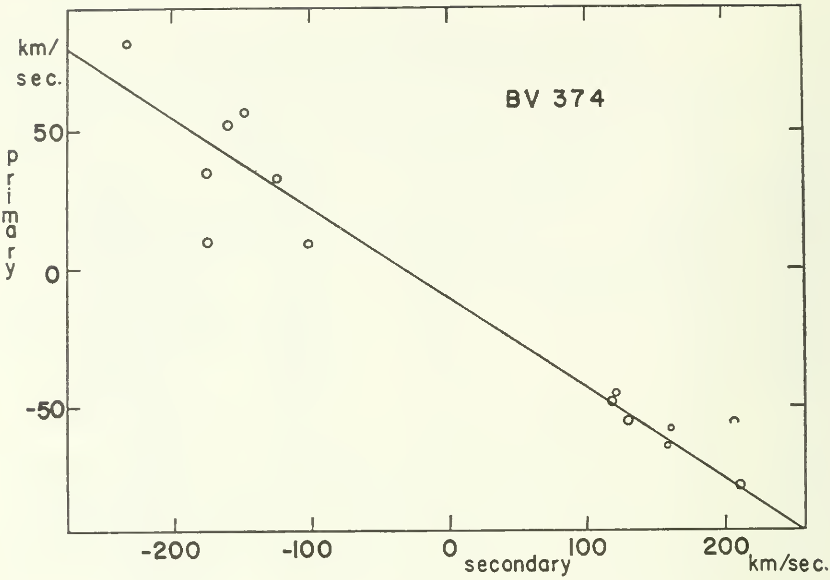

FIGURE 6

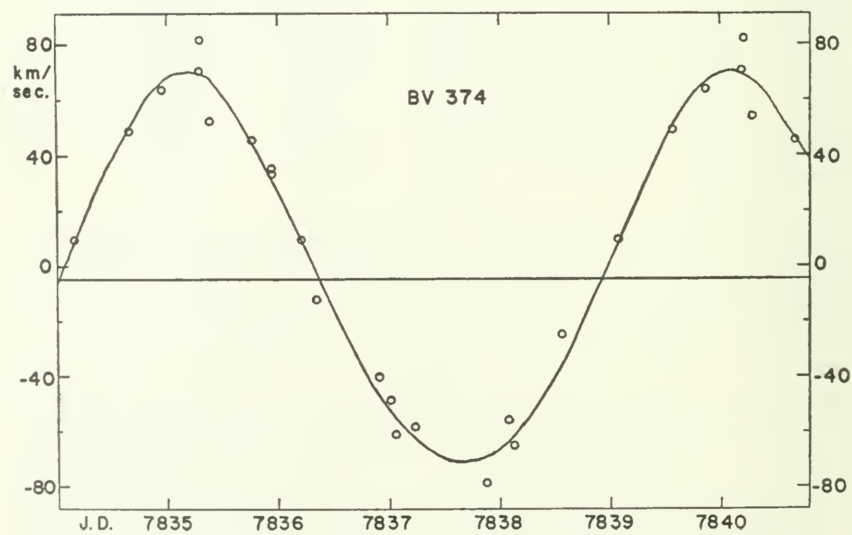

FIGURE 7

TABLE VII

Radial Velocity Observations for BV 374

	Primary		Secondary		
J.D.	V_o km./sec.	$V_o - V_c$ km./sec.	V_o km./sec.	Weight	Phase from final T
2437840.830	+35.0	+ 2.8	−174.6	1.0	0.951
844.817	+70.6	+ 2.2			0.029
855.817	+ 9.7	0.0	−176.1	1.0	1.212
860.862	−12.2	− 9.2			1.355
864.814	+52.4	−14.1	−158.6	1.0	0.391
878.810	+48.7	− 2.7			4.570
882.817	−25.5	+ 2.2			3.668
884.833	+45.7	− 0.2			0.775
895.793	−40.2	+ 6.1	+121.0	0.5	1.917
898.793	+63.9	− 2.5	−147.1	0.7	4.864
899.773	+33.2	+ 4.1	−123.1	0.7	0.949
900.796	−48.4	+ 3.5	+118.9	1.0	2.012
905.750	−60.8	− 6.4	+130.0	1.0	2.057
906.779	−55.9	+ 7.5	+207.7	0.7	3.086
907.767	+ 9.4	+ 0.4	−112.2	0.7	4.074
911.730	−64.8	− 3.0	+159.3	0.5	3.129
915.743	−58.1	+ 4.3	+160.3	0.5	2.233
918.720	+82.2	+ 2.1	−232.8	0.7	0.301
955.661	−78.4	− 9.2	+212.0	1.0	2.881

TABLE VIII

Orbital Elements of BV 374

Element	Preliminary	Final	m.e.
Period	P 4.908756 days	4.908756	
Eccentricity	e 0.060	0.063	0.037
Angle of periastron	ω 45°	346°	34°
Epoch of mean longitude	T_o J.D. 2437834.547	J.D. 2437835.170	0.030
Epoch of periastron	T	J.D. 2437834.970	0.484
Velocity of the system	γ −5.0 km./sec.	−4.9	1.8
Semi-amplitude, primary	K_1 70.0 km./sec.	70.5	2.4
$a_1 \sin i$, primary		4.66×10^6 km.	0.17×10^6
Mass-ratio		2.94	0.27
$m_1 \sin^3 i$, primary		7.58 ☉	0.96
$m_2 \sin^3 i$, secondary		2.58 ☉	0.21

The spectral lines are well defined in the primary component, the most prominent being those of hydrogen, helium, and ionized oxygen. About ten lines were measured on each plate, yielding an average internal probable error of 3 km./sec. for each velocity determination. The secondary component is visible on many of the plates, but is considerably weaker than the primary and consequently gave high internal probable errors of about 9 km./sec. for individual velocity determinations.

The Bamberg period fitted our observations well, and was therefore used here. The remaining elements were obtained from the pre-computed curves of R. K. Young (1936), and then adjusted by a computer programme of least squares employing the method of Sterne (1941) for a single-line binary of non-zero eccentricity.

The method of Wilson (1941) has been employed to estimate the mass-ratio, using the observations weighted according to the probable error of the velocity determination for the secondary component. Agreement within the mean errors was found between the velocity of the system as determined from Wilson's method (-7.8 ± 3.7 km./sec.) and from Sterne's method (-4.9 ± 1.8 km./sec.).

Table VII lists the observed radial velocities and velocity residuals; Table VIII lists the preliminary and final elements; figure 6 shows the velocity curve of the primary component; and figure 7 shows the diagram for Wilson's method of obtaining the mass-ratio.

Acknowledgements

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References

Babcock, H. W. 1960, "Stellar Atmospheres", p. 309 (vol. 6, "Stars and Stellar Systems"), Univ. Chicago Press.

Fresa, A. 1961, *Annali dell' Istituto Universitario Navale di Napoli*, vol. 30.

Lehmann-Filhés, R. 1894, *A.N.*, no. 3242, p. 136.

Sterne, T. E. 1941, *Proc. of Nat. Acad. of Sci.*, vol. 27, p. 175.

Strohmeier, W. 1959, *Kleine Veroffentichungen der Remeis-Sternwarte Bamberg*, no. 24, p. 2.

Strohmeier, W., Knigge, R. and Ott, H. 1962, *Veroffentichungen der Remeis-Sternwarte Bamberg*, vol. 5, no. 13, pp. 3, 10.

Wilson, O. C. 1941, *Ap. J.*, vol. 125, p. 661.

Young, R. K. 1936, Pre-computed Curves for Orbital Elements, unpublished.

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SPECTROSCOPIC AND PHOTOMETRIC ORBITS OF EE PEGASI

GUSTAV A. BAKOS

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SPECTROSCOPIC AND PHOTOMETRIC ORBITS OF EE PEGASI

By Gustav A. Bakos*

Abstract

Spectroscopic and photoelectric observations of this binary system made in 1953 and earlier are recorded here. Improved orbital elements have been obtained as compared with those derived by Wellmann and Beyer (1953). The photometric observations were made in three colours, but the individual observations are of low quality. For this reason the means of the three colour observations have been tabulated.

Introduction

The eclipsing system of EE Peg (H.D. 206155, $\alpha(1900)\ 213^{h}5^{m}.1$, $\delta(1900)\ 8°44'$) was discovered by Hoffmeister (1935) and has been described as an Algol-type variable. From visual observations by Gomi (1940) a preliminary period of 5.256 days has been found. Both spectroscopic and visual observations by Wellmann and Beyer (1953) have shown that the actual period is half of that derived by Gomi.

Wellmann's orbital elements were based on 44 blue-sensitive spectrograms with a dispersion of 65 A./mm. at $H\gamma$ and on ten red-sensitive plates with a dispersion of 156 A./mm. at $H\alpha$ covering the period from June 12, 1951, to January 5, 1952. Furthermore, with the aid of 211 visual estimates within the same time interval a light-curve was derived.

The present observations were made at the David Dunlap Observatory. The spectroscopic material consisted of 48 plates with a dispersion of 66 A./mm. at $H\gamma$ of which 26 were taken by the late F. S. Hogg in 1936–39. The remaining plates were taken in 1952 and 1953. In addition, the star was observed photoelectrically with the earliest version of a photometer attached to the 19-inch reflector. Because an unstabilized power supply was used and the intensity measures were read off a galvanometer the scatter of individual measurements is larger than expected in photoelectric photometry.

The Spectrographic Orbit

The radial velocity measurements have been summarized in Table I. It gives the plate number, the Julian date of observation and the

*Dearborn Observatory, Evanston, Illinois

TABLE I

Plate No.	J.D.	Radial Velocity km./sec.	Phase P^{-1}	O−C km./sec.
1081	2428360.776	− 52.4	.844	− 8.1
1094	362.788	−102.9	.601	− 4.5
1160	375.774	− 95.8	.551	− 6.7
1168	377.776	+ 28.2	.312	+ 9.6
1186	380.736	− 40.5	.439	− 7.5
1195	381.723	− 69.9	.814	−11.6
1208	387.706	+ 60.0	.091	− 8.5
1221	389.732	− 27.4	.862	+ 7.9
1296	400.692	+ 46.2	.032	− 5.0
1304	404.711	− 95.5	.563	− 3.8
1315	408.654	+ 50.0	.061	−11.2
1359	425.576	− 89.4	.500	−15.6
1390	431.628	− 54.4	.802	+ 9.0
1422	440.601	+ 51.0	.216	− 9.3
1556	503.456	+ 68.0	.132	− 4.8
1565	510.469	− 72.1	.800	− 7.7
2514	800.697	+ 60.8	.227	+ 4.1
2742	8864.458	− 62.6	.488	+ 6.7
3821	9179.508	− 00.6	.359	+ 5.8
4590	432.843	− 86.8	.749	− 4.2
4714	465.826	+ 24.5	.299	− 0.8
4735	469.744	− 65.0	.790	+ 2.9
4741	470.732	+ 72.0	.166	+ 1.0
4747	472.781	+ 5.4	.945	− 4.0
4753	476.749	− 54.4	.455	+ 1.2
4790	2429486.755	+ 43.0	.262	0.0
19329	2434217.864	− 27.8	.377	−11.4
20151	551.854	− 50.0	.455	+ 5.6
20168	555.853	+ 42.9	.977	+17.2
20177	557.858	− 88.4	.740	− 3.3
20185	561.855	+ 43.3	.260	− 0.5
20193	563.808	+ 46.0	.004	+ 6.0
20203	565.866	− 50.2	.787	+18.6
20223	569.867	+ 28.0	.309	+ 7.8
20297	576.869	+ 16.0	.973	− 8.3
20321	580.875	− 62.0	.497	+10.7
20337	583.874	− 96.6	.638	+ 2.9
20339	584.772	+ 33.9	.980	+ 6.2
20345	586.883	− 64.4	.783	+ 6.6
20352	589.889	− 6.5	.927	− 6.2
20392	600.624	+ 60.5	.012	+17.6
20400	600.866	+ 79.3	.104	+ 8.7

TABLE I—(*Concluded*)

Plate No.	J.D.	Radial Velocity km./sec.	Phase P^{-1}	O−C km./sec.
20405	2434601.668	− 34.4	.409	− 1.1
20410	601.872	− 67.1	.486	+ 1.4
20418	603.891	+ 45.0	.255	− 0.9
20445	609.624	− 48.8	.436	− 2.0
20454	610.810	− 21.0	.887	+ 1.1
20526	2434622.640	− 30.0	.388	− 7.9

radial velocity reduced to the sun. The phase was calculated by means of the formula

$$\text{Phase} = (\text{J.D} - .2400000)P^{-1}$$

where $P^{-1} = 0.3804848$/day corresponding to the period $P = 2.6282253$ days. This period was found from both photometric and spectroscopic data. The last column gives the $O-C$'s.

According to Wellmann the spectral type of EE Peg is A4V. On an average about 15 lines were measured for radial velocity determination including the K line, the calcium line at λ4227, the Mg II line at λ4481, and a large number of iron lines. The hydrogen lines were generally broad and therefore less suitable for accurate measurements.

Preliminary orbital elements have been obtained graphically. For a definitive orbit differential corrections to the elements have been calculated by the method of least squares. The final elements and their mean errors are given in Table II. The velocity curve has been plotted in figure 1.

The calculated velocity curve gives a good representation of the observed velocities by both Wellmann and the writer. However, Wellmann's points exhibit a much larger scatter. The run of the writer's $O-C$'s as a function of time has been plotted in figure 2. The mean value of Wellmann's $O-C$'s has been indicated by an open circle at J.D. 3800. It appears from figure 2 that the earlier $O-C$'s are predominantly negative while the later are positive as shown by the crosses, their mean values. On the other hand, Wellmann's mean of 44 observations is definitely negative. At any rate it would require only a slight adjustment of the adopted period to make the mean $O-C$'s zero.

Photometric Orbit

A single comparison star was used, H.D. 205923 of spectral type A2 and magnitude 8.2 about 40 minutes of arc north of the variable. The

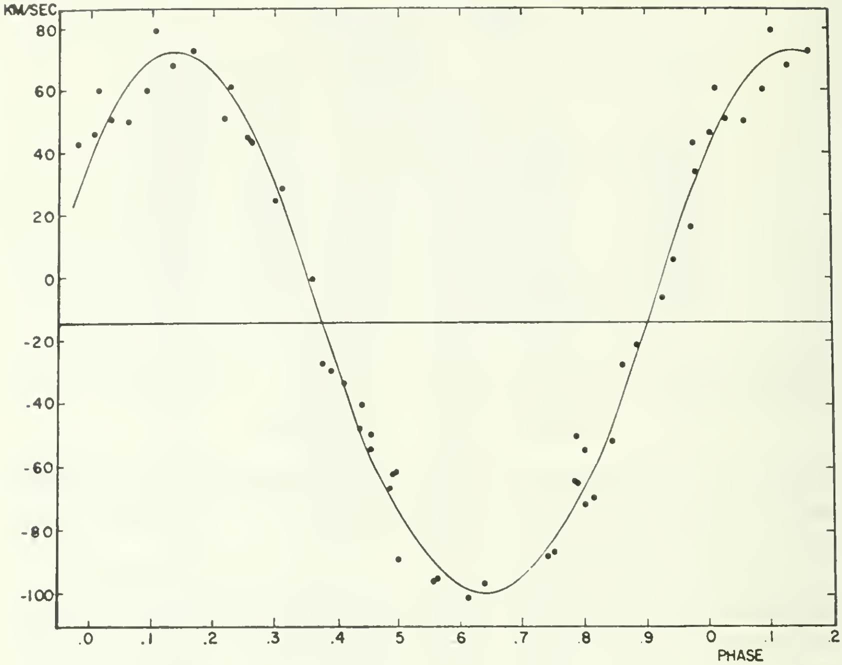

FIG. 1—The velocity curve of EE Pegasi.

observations were made in three colours: blue, green and yellow spectral range. The effective wave-lengths of these colours were $\lambda\lambda$4300, 4900 and 5200. Originally the inclusion of two more regions, the UV and the red, was planned; however, the measured deflections were small and the measurements unreliable. Since the photometer had no provision for selective shunting of the galvanometer, the sensitivity of the instrument was adjusted by changing the voltage of the photomultiplier tube on practically every night. Because the

TABLE II

SPECTROGRAPHIC ELEMENTS OF EE PEGASI

Periastron passage	$T = 2429486^{d}.408 \pm .023$
Period	$P = 2^{d}.6282253$
Velocity of the system	$\gamma = -13 \cdot 43$ km./sec.
Semi-amplitude	$K = 86 \cdot 15$ km./sec. ± 0.29
Longitude of periastron	$\omega = 357^{\circ}.71 \pm 3^{\circ}.15$
Eccentricity	$e = 0 \cdot 03 \pm 0 \cdot 003$
Semi-major axis	$a \sin i = 3 \cdot 11 . 10^{6}$ km.
Mass-function	$f(m) = 0 \cdot 174 \odot$

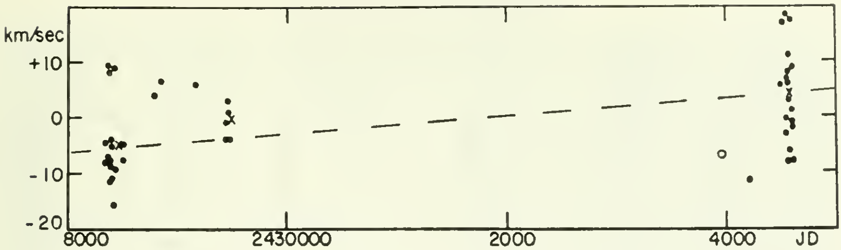

FIG. 2—The run of O – C as a function of time.

colour difference between the variable and the comparison stars is zero and observations were limited to moderate hour angles no correction for differential extinction appeared to be necessary. Also, since the light curves in all three colours appeared to be identical they were combined into a single light curve for which the individual points as a function of phase can be found in Table III. In figure 3 the mean light curve has been plotted, the Δm versus the phase. The latter was computed by the same formula as in the previous section.

TABLE III

J.D.	Phase	Δm	J.D.	Phase	Δm
2434582.677	0.183	−1.272	2434595.744	0.154	−1.263
.693	.189	−1.269	4600.739	.055	−1.272
.713	.193	−1.271	.758	.062	−1.274
.730	.203	−1.276	.775	.069	−1.281
.747	.209	−1.269	.792	.075	−1.275
.762	.215	−1.266	.814	.083	−1.277
4582.779	.222	−1.272	.829	.089	−1.286
4583.739	.587	−1.276	.845	.095	−1.278
.756	.593	−1.276	.863	.102	−1.278
.774	.600	−1.286	4600.881	.109	−1.279
.791	.607	−1.284	4603.733	.194	−1.275
.823	.619	−1.290	.747	.199	−1.275
.839	.625	−1.276	.762	.205	−1.271
4583.857	.632	−1.263	.776	.210	−1.265
4586.638	.690	−1.274	.791	.216	−1.277
.654	.696	—1.268	.804	.221	−1.280
.670	.702	−1.270	.820	.227	−1.272
.686	.708	−1.265	.836	.233	−1.272
4586.704	.715	−1.270	.851	.239	−1.271
4595.687	.133	−1.255	4603.872	.247	−1.264
.708	.141	−1.272	4605.715	.948	−1.272
.729	.149	−1.278	.731	.954	−1.279

TABLE III—*Continued*

J.D.	Phase	Δm	J.D.	Phase	Δm
2434605.748	0.961	−1.278	2434621.644	0.009	−1.283
.764	.967	−1.278	.661	.015	−1.296
.790	.977	−1.280	.680	.023	−1.295
.807	.983	−1.280	.693	.028	−1.288
.826	.990	−1.282	.709	.034	−1.286
4606.629	.296	−1.273	.724	.039	−1.293
4606.648	.303	−1.261	.741	.046	−1.290
.684	.317	−1.273	.756	.051	−1.284
.715	.329	−1.270	.772	.058	−1.272
.730	.334	−1.262	.786	.063	−1.274
.746	.341	−1.246	4622.561	.358	−1.051
.764	.347	−1.199	4622.573	.362	−0.925
.780	.353	−1.132	.588	.368	−0.838
.802	.362	−1.001	.602	.373	−0.762
.818	.368	−0.840	.617	.379	−0.654
.833	.374	−0.688	.633	.385	−0.598
.849	.380	−0.610	.647	.390	−0.601
.866	.386	−0.595	.681	.403	−0.892
4606.881	.392	−0.617	.693	.408	−0.981
4607.724	.713	−1.272	.706	.413	−1.059
.742	.719	−1.272	.720	.418	−1.142
.756	.725	−1.269	.735	.424	−1.200
.771	.730	−1.262	.748	.429	−1.234
.786	.736	−1.264	.763	.435	−1.261
.801	.742	−1.271	.777	.440	−1.270
.819	.749	−1.270	.793	.446	−1.276
4607.835	.755	−1.274	.807	.451	−1.272
4614.764	.391	−0.611	4622.822	.457	−1.270
.779	.397	−0.716	4623.573	.743	−1.260
.795	.403	−0.879	.586	.748	−1.255
.811	.409	−0.972	.602	.754	−1.266
.831	.417	−1.124	.615	.759	−1.267
4614.849	.424	−1.218	.632	.765	−1.262
4618.588	.846	−1.236	.646	.771	−1.273
.602	.851	−1.196	.661	.776	−1.270
.620	.858	−1.155	.681	.784	−1.270
.638	.865	−1.140	.696	.790	−1.270
.652	.870	−1.127	.709	.795	−1.268
.668	.877	−1.091	.722	.799	−1.273
.718	.896	−1.115	.735	.804	−1.276
4618.732	.901	−1.157	.749	.810	−1.258
4621.586	.987	−1.273	.762	.815	−1.266
.600	.992	−1.251	.776	.820	−1.235
.614	.997	−1.266	.805	.831	−1.236
.627	.002	−1.276	4623.818	.836	−1.227

TABLE III—*Continued*

J.D.	Phase	Δm	J.D.	Phase	Δm
2434626.617	0.901	−1.158	2434630.716	0.461	−1.275
.634	.907	−1.223	.729	.465	−1.267
.653	.915	−1.237	.743	.471	−1.272
.669	.921	−1.258	.756	.476	−1.279
.686	.927	−1.248	.772	.482	−1.272
.699	.932	−1.278	.785	.487	−1.270
.712	.937	−1.280	.798	.492	−1.282
.725	.942	−1.284	.812	.497	−1.275
.744	.949	−1.274	4630.827	.503	−1.275
.758	.955	−1.295	4631.580	.789	−1.275
.776	.961	−1.305	.592	.794	−1.281
.791	.967	−1.297	.606	.799	−1.281
.806	.973	−1.278	.620	.805	−1.281
4626.820	.978	−1.279	.641	.813	−1.275
4628.556	.639	−1.276	.656	.818	−1.246
.572	.645	−1.279	.670	.824	−1.257
.591	.652	−1.278	.682	.828	−1.242
.606	.658	−1.275	.697	.834	−1.259
.624	.665	−1.274	.711	.839	−1.229
.640	.671	−1.274	.727	.845	−1.221
.659	.678	−1.290	.740	.850	−1.195
.672	.683	−1.274	.756	.856	−1.172
.686	.688	−1.274	4631.788	.868	−1.116
.697	.692	−1.272	4635.546	.298	−1.266
.708	.697	−1.274	.558	.303	−1.260
.720	.701	−1.264	.575	.309	−1.260
.737	.708	−1.277	.583	.312	−1.256
.753	.714	−1.277	.597	.318	−1.260
.768	.719	−1.274	.611	.323	−1.257
.782	.725	−1.270	.628	.329	−1.260
.797	.730	−1.269	.639	.334	−1.260
.813	.737	−1.283	.656	.340	−1.245
4628.828	.742	−1.262	.667	.344	−1.235
4630.551	.398	−0.753	.680	.349	−1.191
.563	.402	−0.910	.690	.353	−1.153
.577	.408	−1.028	.704	.358	−1.051
.589	.412	−1.100	.717	.363	−0.945
.606	.419	−1.157	.729	.368	−0.858
.619	.424	−1.184	.740	.372	−0.776
.638	.431	−1.234	4635.754	.377	−0.686
.649	.435	−1.262	4637.692	.115	−1.281
.663	.440	−1.261	.704	.119	−1.275
.675	.445	−1.270	.718	.125	−1.272
.687	.450	−1.276	.733	.130	−1.283
.699	.454	−1.270	.763	.142	−1.280

TABLE III—*Concluded*

J.D.	Phase	Δm	J.D.	Phase	Δm
2434637.774	0.146	−1.292	2434647.605	0.886	−1.078
.788	.151	−1.268	.616	.891	−1.110
4638.548	.440	−1.275	.629	.896	−1.124
.562	.446	−1.283	.640	.900	−1.139
.615	.466	−1.265	4647.652	.904	−1.197
.627	.471	−1.261	4648.538	.241	−1.273
.638	.475	−1.261	.550	.246	−1.274
.649	.479	−1.261	.565	.252	−1.278
.663	.484	−1.268	.580	.257	−1.270
.674	.488	−1.269	.613	.270	−1.263
.688	.494	−1.269	.624	.274	−1.270
.699	.498	−1.274	.636	.279	−1.273
.715	.504	−1.274	.642	.281	−1.273
.726	.508	−1.268	.660	.288	−1.273
.738	.513	−1.270	.672	.292	−1.276
.749	.517	−1.275	.686	.298	−1.273
.763	.522	−1.272	.697	.302	−1.266
.774	.526	−1.269	.714	.308	−1.266
4638.788	.532	−1.279	.726	.313	−1.256
4643.545	.342	−1.192	.739	.318	−1.268
.579	.355	−1.090	.752	.323	−1.260
.595	.361	−0.958	.765	.328	−1.262
.609	.366	−0.856	4648.778	.333	−1.273
.620	.370	−0.778	4649.536	.621	−1.273
.631	.374	−0.692	.547	.625	−1.267
.644	.379	−0.627	.562	.631	−1.269
.668	.389	−0.593	.576	.636	−1.266
.680	.393	−0.642	.594	.643	−1.271
.697	.400	−0.754	.606	.648	−1.274
.711	.405	−0.927	.618	.652	−1.268
.724	.410	−1.025	.629	.657	−1.268
.736	.414	−1.119	.648	.664	−1.269
4643.788	.434	−1.260	.660	.668	−1.277
4647.527	.857	−1.193	.674	.674	−1.273
.539	.861	−1.145	.684	.677	−1.274
.552	.866	−1.138	.699	.683	−1.270
.563	.870	−1.116	.713	.689	−1.265
.581	.877	−1.086	4649.727	.694	−1.271
.593	.882	−1.076			

There are 12 epochs of primary minima available including those observed by Wellmann covering a total of 290 periods. These have been listed in Table IV, together with the $O-C$'s based on the period derived by the writer. The systematically decreasing deviations in

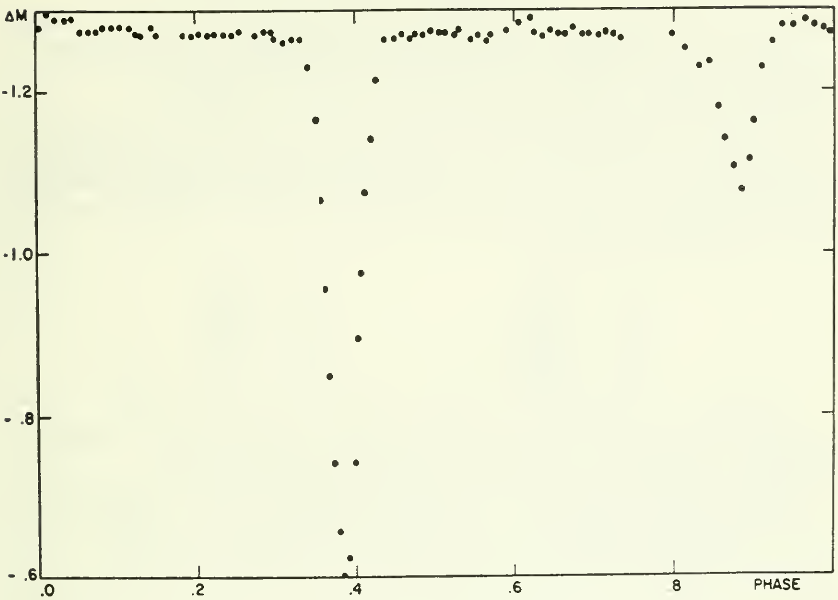

FIG. 3—The mean light curve of EE Pegasi.

TABLE IV

EPOCHS OF PRIMARY MINIMA

J. D.	No. of Periods Elapsed	O−C
243 3881.509	−290	+0ᵈ.038
889.394	−287	+0.039
910.400	279	+0.019
923.537	274	+0.015
931.417	271	+0.010
939.297	268	+0.005
947.176	265	0.000
3960.316	260	−0.001
4606.863	14	+0.002
622.633	−8	+0.003
635.770	−3	−0.001
643.656	0	0.000

Wellmann's observations are within the uncertainty of visual estimates of the times of minima.

The light curve shows two unequal minima, the secondary minumum being quite shallow and, in addition, not too well observed. Consequently, only the primary minimum was used for a solution of the photometric orbit, with the added information for the depth of the secondary minimum. It appears that the eclipse is either partial or grazing. Outside eclipses the brightness remains constant.

Following the Russell-Merrill (1950, 1952) method for the derivation of preliminary orbital elements, it appears that the primary eclipse is a transit with α_0 very close to 1. Assuming a limb-darkening coefficient $x = 0.6$ the light curve during the primary minimum can be represented by the following elements:

$$k = 0.85 \qquad L_g = 0.784$$
$$r_g = 0.166 \qquad L_s = 0.216$$
$$r_s = 0.141 \qquad \Delta M = 1^{m}.40$$
$$i = 88^{\circ}.57$$

Since the spectral type of the primary component is A4V, the secondary component is of the spectral type about F5V.

It should be pointed out that the new orbital elements differ from those derived by Wellmann. It has been found that for the same value of α_0 and the limb-darkening coefficient Wellmann's ratio of the radii, $k = 0.666$, is too small to match the observed and the computed light curve adequately. The deviations are quite large in the wings of the primary minimum. On the other hand, the present value for k should be considered as tentative until a more accurate light curve has been derived.

Conclusion

There is a need for new and more accurate photometric observations of this eclipsing system. Although this writer's data are better than the visual estimates of Wellmann, sections of the light curve have been covered inadequately or not at all. Also, new observations would provide additional epochs for improving the period of the system.

References

Gomi, K. 1940, *Beob. Zirk.*, vol. 22, p. 39.
Hoffmeister, C. 1935, *Astr. Nach.*, vol. 255, p. 401.
Merrill, J. E. 1950, *Princeton Contr.*, no. 23.
Russell, H. N. and Merrill, J. E. 1952, *Princeton Contr.*, no. 26.
Wellmann, P. 1953, *Zs. f. Ap.*, vol. 32, p. 81.

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THE RADIAL VELOCITIES AND SPECTRAL CLASSES OF 55 KAPTEYN AREA FUNDAMENTAL STARS IN HIGH GALACTIC LATITUDES

JOHN F. HEARD

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THE RADIAL VELOCITIES AND SPECTRAL CLASSES OF 55 KAPTEYN AREA FUNDAMENTAL STARS IN HIGH GALACTIC LATITUDES

By John F. Heard

Abstract

In 1954 a programme was set up for the determination of the radial velocities of 55 fundamental stars in Kapteyn's Selected Areas 13-15, 29-35, 53-60, that is, in the selected areas near the north galactic pole. The stars selected were those brighter than photographic magnitude 10.01 (on the *Bergedorfer Spectral-Durchmusterung* scale) which are listed in Hins' (1934) Catalogue in the stated areas and for which no radial velocities were known in 1954. Observations were obtained over a period of ten years and the results both of radial velocity and of MK spectral classification are presented here.

Observations and Results

Spectrograms. The instrument used to obtain the spectrograms was the one-prism Hilger spectrograph with a camera lens of 12.5 inches focal length giving a dispersion of 66 A./mm. at Hγ. With a slit which gave a projected width of 20μ the spectra of these 9th to 10th magnitude stars required exposures of two hours or more. The rule was to observe the stars at least four times in different seasons. Actually most of the stars were observed more than four times.

Radial Velocities. The spectrograms were measured for radial velocity by the standard technique used at this Observatory. In addition to the writer the following persons did appreciable shares of the measuring: Miss Küli Milles, Messrs. W. Russell, S. C. Morris, D. Crampton, M. P. FitzGerald, H. Mairo. As a general rule between 10 and 20 star lines were measured except for the B- and A-type stars, and the probable errors of the means mostly ranged between 1 and 4 km./sec. as computed from the inter-agreement of the lines. Decisions as to constancy or variability of the velocities were made not by any fixed rule but by judgement based on experience in measuring similar spectrograms on other programmes.

Spectral Classification. All spectra were classified by the writer on the MK system with the aid of an almost complete set of spectrograms of the MK standards taken with the same dispersion.

The Tabulations. Table I lists the stars. Column 1 gives the Kapteyn Selected Area number and the star number in Hins' (1934) catalogue.

TABLE I

S.A. and Hins No.	H.D. or B.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
		h m	° ′						
53/567	82011	9 27.1	+30 16	10.09	B9 III	+31.1 v?	2.7	5	II
53/568	82069	9 27.5	29 48	9.45	F8 V	Var.		6	II
53/569	29°1907	9 27.6	29 20	9.89	F5 V	Var		8	II
53/570	29°1908	9 28.2	29 31	9.93	K0 III	− 1.2	0.8	4	
53/571	30°1875	9 29.6	29 48	9.73	F3 V	Var.		6	II
53/573	82570	9 30.6	+29 06	10.02	G8 III:	+11.0 v?	2.8	4	II
29/301	83697	9 38.4	44 26	9.72	G8 III	+29.0 v?	2.1	7	II
29/302	44°1898	9 39.8	44 04	9.85	G0 V	−10.0	2.6	5	
29/303	45°1753	9 39.9	45 16	9.87	A2 V	Var.		6	II
29/304	84059	9 40.6	44 56	7.50	F0 III	Var.		5	II
29/306	84219	9 41.7	+44 39	8.52	G0V	−28.5	2.0	5	
29/307	45°1758	9 41.9	45 10	9.99	F8 V	Var.		6	II
29/308	45°1761	9 43.4	44 36	9.88	F8 V	+ 4.5	2.9	5	
29/310	45°1763	9 43.6	45 18	9.95	F8 V	−26.0	0.9	4	
29/311	44°1904	9 44.2	44 28	9.39	A9 III	+ 0.4 v?	3.2	5	II
54/579	30°2024	10 26.9	+29 46	9.66	F8 V	− 9.0	3.0	4	
30/312	92124	10 36.0	45 06	9.76	K5 III	+58.9	2.9	8	N
30/317	45°1859	10 41.3	44 56	9.59	F3 V	Var.		21	N
13/117	95866	11 01.6	59 10	9.86	G0 IV	+87.4	1.0	5	
13/118	95975	11 02.2	59 50	9.85	F7 IV	−31.1	2.1	4	
13/119	96093	11 02.9	+60 06	9.56	F5 III	− 1.6	1.8	4	
13/122	96950	11 07.7	59 10	10.08	G8 IV	−52.6	2.0	5	
13/124	97420	11 10.6	59 25	9.32	F6 V	+ 6.0	3.3	4	
13/125	97438	11 10.7	60 01	9.81	F0 III	−29.6	1.3	4	
55/587	30°2175	11 32.4	29 42	9.78	G0 V	Var.		8	II
31/322	44°2112	11 35.9	+44 22	9.65	F6 V	−32.2 v?	2.4	7	II
31/327	101674	11 39.6	44 25	9.12	F6 III	−29.5	1.4	6	
56/596	105020	12 03.0	28 47	8.91	K3 III	−38.7 v?	1.7	9	II
32/333	111851	12 49.4	44 18	9.27	F6 IV	− 6.6	2.1	5	
32/335	112297	12 52.9	44 34	9.48	F8 V	− 5.6	3.1	5	
57/600	113995	13 04.8	+28.59	9.76	K3 III	−23.9	1.7	4	
57/601	114059	13 05.3	29 43	10.06	G8 V:	−21.8	1.1	3	
57/602	114071	13 05.3	29 44	10.08	F7 V	Var.		7	II
14/133	117845	13 29.7	59 13	8.36	G2 V	+ 3.4	2.8	6	
33/341	45°2134	13 48.8	44 37	9.90	F8 IV	−23.7	1.9	6	
33/344	45°2137	13 52.1	+44 58	9.57	F5 V	+ 2.2	2.2	5	
33/347	121933	13 55.6	45 24	9.28	F3 V	− 4.0	2.9	6	
58/617	29°2495	14 04.8	29 30	10.00	F7 IV	Var.		6	II
34/349	130988	14 47.8	45 05	9.17	G8 V	+19.8	1.3	6	
34/352	131381	14 50.0	45 23	9.68	F6 IV	−33.4	1.6	6	
34/353	131447	14 50.4	+44 26	9.88	K0 IV	−46.6	2.2	5	
34/355	131861	14 52.6	45 30	7.64	F5 V	Var.		20	N
34/356	132046	14 53.8	45 06	9.13	F0 III	− 7.8	0.3	4	
59/625	133965	15 04.3	29 23	9.42	F6 V	−19.8	1.6	8	
15/134	135721	15 12.6	60 08	9.60	F2 II	Var.		6	II

TABLE I—*Continued*

S.A. and Hins No.	H.D. or B.D.	R.A. (1950)	Dec. (1950)	Ptg. Mag.	Class	Velocity (km./sec.)	P.E.	Pl.	Ref.
		h m	° ′						
15/135	135741	15 12.8	+59 43	9.45	F5 V	Var.		7	II
15/136	135962	15 14.1	59 37	9.69	G8 II	−13.1 v?	2.7	5	II
15/137	60°1598	15 15.4	59 57	9.84	F5 II	−31.1	0.9	4	
15/138	136244	15 15.6	60 17	9.08	K3 III	Var.		8	II
15/140	136617	15 17.7	59 42	9.75	K5 V	−64.3	1.4	4	N
15/144	60°1611	15 22.9	+60 05	9.98	F8 V	−20.5 v?	3.1	5	II
35/360	45°2344	15 50.2	44 51	9.67	F3 V	−38.0 v?	3.3	6	II
35/364	142592	15 51.9	45 06	9.25	A4 V	Var.		10	II
60/634	143585	15 58.2	30 15	10.08	K0 III	− 1.9	2.3	4	
60/635	29°2751	15 58.7	29 42	9.99	A9 III:	−20.4	2.0	6	

Notes to Table I

H.D.92124 Exclusion of one discordant measure (of 76.4 km./sec.) would change the mean velocity to +55.8 km./sec. and would reduce the P.E. to 0.7 km./sec.

B.D.45°1859 Twenty-one observations show the velocity to be variable; the period seems to be about 22.7 days, the half-range 26 km./sec., and the velocity of the system—81 km./sec. This would make this star a rare combination of high-velocity and binary.

H.D.131861 Twenty observations show the velocity to be variable; preliminary elements are: period 3.55 days, half-range 72 km./sec., velocity of the system—20 km./sec.

H.D.136617 The G-band is weak.

Columns 2 to 4 are self-explanatory. Column 5 gives the photographic magnitudes as listed in the *Bergedorfer Spectral-Durchmusterung*. Column 6 is our MK classification. Column 7 lists the mean radial velocities for those stars which are believed to have constant velocities and for stars whose velocities *may* be variable (*v*?), but no mean velocities are listed for those stars which are more certainly variable. (The individual velocity measures are tabulated in Table II both for stars which are of doubtful and of certain velocity variability.) Column 7 lists the probable errors of the means computed from the inter-agreement of plate measures, and column 8 gives the number of plates measured. Column 9 refers to the notes (*N*) and to inclusion of the star in Table II.

TABLE II

Stars With Definitely (Def.) or Possibly (Poss.) Variable Velocity

Star H.D. or B.D.	Julian Day (243...)	Velocity km./sec.
82011	5559.639	+ 17.1
(poss.)	5783.892	+ 28.7
	6222.819	+ 44.7
	7747.662	+ 43.0
	8061.806	+ 22.1
82069	5146.788	+ 9.0
(def.)	5514.867	+ 26.6
	6255.708	+ 6.9
	6323.583	+ 9.6
	7734.726	− 3.6
	8045.791	+ 14.0
29°1907	5527.731	− 19.2
(def.)	5874.805	− 31.0
double lines	6271.772	− 28.5
	6650.749	− 47.7
	7771.622	− 97.7
		+ 95.8
	7997.850	−106.2
		+ 68.7
	8046.891	− 21.4
30°1875	5573.631	− 8.0
(def.)	5587.605	− 12.0
	6644.696	+ 3.4
	6672.658	− 27.8
	7750.631	− 5.2
	8046.762	− 20.0
82570	5551.659	+ 10.2
(poss.)	5881.768	+ 11.2
	6655.633	+ 20.8
	6673.576	+ 1.9
83697	5533.713	+ 33.5
(poss.)	5564.660	+ 32.8
	6302.610	+ 33.7
	6635.635	+ 12.3
	7410.603	+ 32.5
	8453.732	+ 24.5
	8478.695	+ 33.9
45°1753	5553.651	− 67.7
(def.)	5583.623	− 63.7
	6309.594	− 29.1
	6646.702	+ 75.5
	7335.778	+117.4
	7742.684	+ 38.8
84059	5215.540	− 20.0
(def.)	5538.631	− 38.0
	7044.578	− 42.0
	8085.753	− 18.8
	8473.680	− 35.5
45°1758	5215.555	− 10.8
(def.)	5557.704	− 16.6
	6656.647	− 39.2
	7746.668	− 51.6
	7779.600	− 22.2
	7780.644	− 17.4
44°1904	5141.786	− 2.7
(poss.)	5601.604	+ 13.2
	6638.688	− 15.0
	7341.814	+ 5.6
	7726.699	+ 0.8
30°2175	5527.829	+ 13.0
(def.)	5551.755	+ 53.0
	6222.897	+ 1.6
	6624.823	+ 46.2
	7410.731	+ 40.1
	7412.717	+ 52.7
	8058.894	+ 30.6
	8461.786	+ 7.6
44°2112	4883.626	− 21.8
(poss.)	5533.858	− 27.5
	5602.626	− 21.0
	6309.708	− 41.9
	7427.642	− 35.4
	7751.831	− 34.3
	8500.725	− 43.2

TABLE II—*Continued*

Star H.D. or B.D.	Julian Day (243...)	Velocity km./sec.	Star H.D. or B.D.	Julian Day (243...)	Velocity km./sec.
105020	2989.760	− 31.9	135962	4881.793	− 20.5
(poss.)	3015.697	− 37.0	(poss.)	5261.722	− 5.7
	3031.646	− 28.9		6308.892	− 7.2
	4089.776	− 44.4		6637.891	− 25.0
	4558.635	− 33.8		7416.864	− 7.0
	4562.624	− 40.4			
	5142.934	− 53.5	136244	4880.677	− 51.5
	5559.757	− 35.7	(def.)	5283.649	− 48.3
	5587.708	− 43.1		6672.848	− 29.2
				7087.738	− 60.7
114071	5251.663	− 6.9		7761.842	− 51.4
(def.)	5552.865	− 24.4		7765.781	− 49.9
	5890.923	− 27.1		8134.726	− 56.9
	6308.866	− 12.5		8486.802	− 35.6
	6635.865	− 34.2			
	7378.842	− 22.3	60°1611	4922.685	− 24.8
	7749.839	− 22.9	(poss.)	5285.685	− 4.8
				6644.846	− 16.4
29°2495	4908.625	− 37.5		6680.848	− 32.2
(def.)	5226.790	− 58.4		7791.778	− 24.2
	5559.868	− 39.9			
	6271.876	− 43.6	45°2344	4886.796	− 27.3
	7057.631	− 74.8	(poss.)	5260.708	− 39.5
	7398.836	− 67.7		5601.797	− 41.0
				5608.802	− 25.4
135721	4880.747	− 13.3		8467.857	− 48.6
(def.)	5261.625	− 7.5		8489.880	− 46.0
	6309.884	− 36.6			
	6673.780	− 4.9	142592	4881.856	− 16.1
	7057.807	− 28.6	(def.)	5215.887	− 10.4
	7389.832	− 5.0		5283.689	− 79.3
				5602.819	− 46.9
135741	4881.728	− 10.8		7056.839	− 46.3
(def.)	5295.630	− 28.5		7057.685	− 19.2
	6637.936	− 33.0		8125.832	+ 0.7
	6673.853	− 17.1		8477.881	+ 1.3
	7416.786	− 9.2		8502.811	+ 36.3
	7747.784	− 12.5		8512.776	− 23.4
	8486.885	− 0.6			

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Reference

Hins, C. H., 1934, *Leiden Observatory Annals*, vol. 15, part 4.

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VOLUME II NUMBER 17

A STUDY OF THE VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 14

I. PERIODS AND LIGHT CURVES OF TWENTY VARIABLES

HELEN SAWYER HOGG
AND
AMELIA WEHLAU

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A STUDY OF THE VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 14

I. Periods and Light Curves of Twenty Variables

By Helen Sawyer Hogg and Amelia Wehlau

The globular cluster Messier 14, NGC 6402, (R.A. $17^h\ 35^m\!.0$, Dec. $-03°\ 15'$, 1950) is one of the clusters very rich in variable stars. It is exceeded in number of variables by only seven other clusters at present. Seventy-two variables were discovered by H. B. Sawyer (1938) from a series of plates taken with the 72-inch reflector of the Dominion Astrophysical Observatory at Victoria. A preliminary report of work on their periods appeared at the same time (Sawyer 1937), but circumstances delayed publication of further work until now.

For the past three years we have been making a study of the variables in the cluster to determine their periods and the form of their light curves. A total of 258 plates is now available, virtually all of which have been taken by one of us (H.S.H.). Of these, 31 were taken with the 72-inch reflector of the Dominion Astrophysical Observatory, 211 with the 74-inch reflector and 9 with the 19-inch of the David Dunlap Observatory, 2 with the 36-inch Steward Observatory reflector, and 5 early Mount Wilson plates were taken by F. G. Pease and H. Shapley. These plates span an interval of 52 years.

Four additional variables have now been found by Amelia Wehlau, bringing the total to 76. These are indicated on figure 1, and are given in Table I of this paper. The first 72 variables were identified in the original paper. One of the first results of the renewed study was the discovery of a nova (by A.W.) on the plates of 1938 taken with the David Dunlap Observatory 74-inch (Sawyer Hogg and Wehlau 1964).

All the available plates have been measured (by A.W.) with the Becker iris photometer at the Hume Cronyn Memorial Observatory of the University of Western Ontario. The magnitudes of the sequence previously published have now been revised from five plates taken with superimposed exposures on both the cluster and Kapteyn Area 61, one of the areas where the magnitude values have been standarized to the fainter magnitudes (Stebbins, Whitford and Johnson 1950). The comparison stars are identified on figure 1, and their revised magnitudes are given in Table II, which includes four auxiliary stars added to the original sequence.

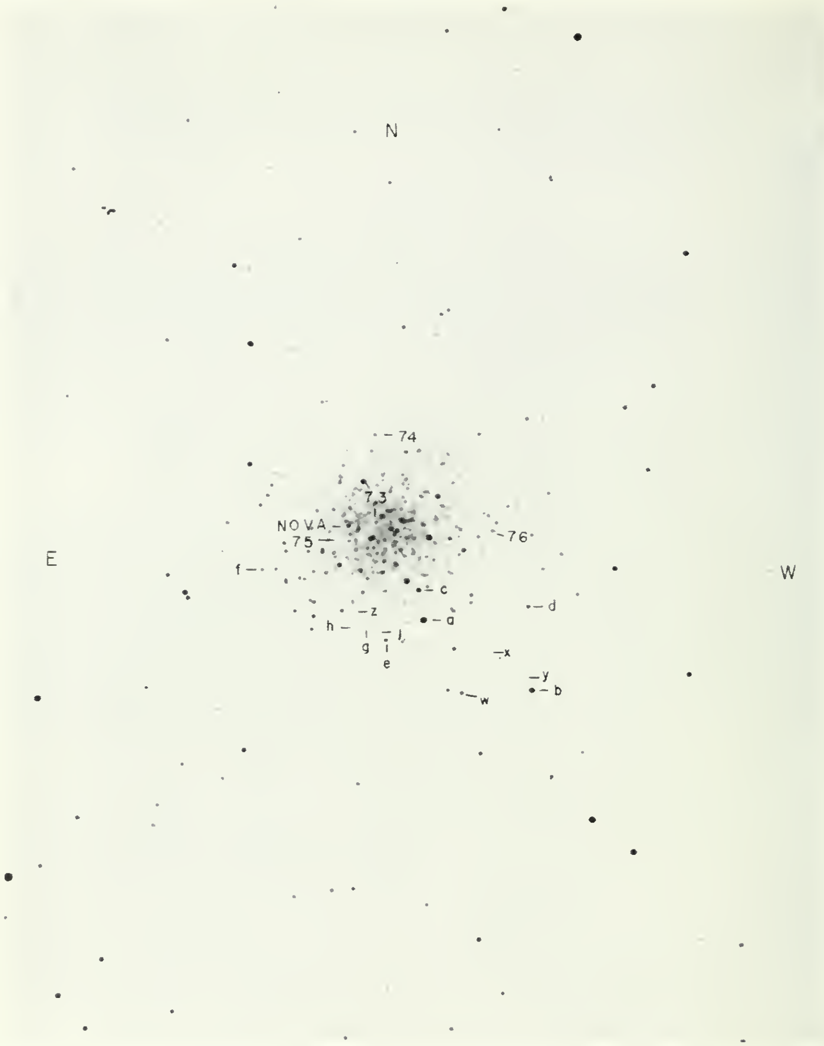

FIG. 1—The globular cluster Messier 14, photographed with the 74-inch reflector of the David Dunlap Observatory on June 23, 1938, when the nova was visible. (Plate 3263, exp. 40 min.) Four new variables, and comparison stars are also identified. Scale of the figure, 7″.0/mm.

The variables in this paper are mainly those for which preliminary results were given in 1937, with many additional observations obtained since. They have large ranges, and three bright Cepheids with periods over one day are among them. Many of the preliminary periods derived

TABLE I

NEW VARIABLE STARS

Variable No.	Co-ordinates x″	y″	Magnitudes Max.	Min.	Mean	Remarks
73	+05	+07	16.5	18.0	17.25	Bright irregular?
74	+07	+91	16.5	17.2	16.85	Bright irregular?
75	+35	−12	16.7	18.5	17.60	RR Lyrae
76	−105	+03	16.1	17.0	16.55	Short period Cepheid
Nova	+30	+04	16 (observed)			Found only on plates of 1938

TABLE II

MAGNITUDES OF SEQUENCE STARS

Star	Co-ordinates x″	y″	Mean Mag. (pg)
a	−43	−86	14.52
b	−146	−150	14.70
c	−39	−57	15.35
d	−141	−71	15.85
e	−9	−104	16.17
f	+110	−42	16.71
g	+11	−92	17.46
h	+21	−93	17.98
j	+2	−99	18.42
w	−80	−152	16.20
x	−105	−115	17.40
y	−139	−138	17.55
z	+24	−79	17.56

some years ago are being brought up to date with the help of the IBM 7040 at the University of Western Ontario. Even though the magnitudes have been determined with the photometer it will be difficult to get periods for many of the stars with small ranges, located in the congested central region of the cluster, where background corrections are large; the congestion in the central region, even on a scale of 22″.43 to the millimetre, is severe. Although the cluster has a relatively large angular diameter of 6′.7, the stars are faint, with the RR Lyrae stars ranging mostly from the 17th magnitude at maximum to the 18th at minimum. Since the twenty stars which appear in this paper have been selected for large ranges and unobscured position, this material alone is not suitable for a discussion of the frequency of periods in this cluster.

Table III gives the observations on all available plates for the following twenty variables, numbers 1, 2, 4, 5, 7, 9, 10, 11, 15, 16, 19, 22, 23, 24, 25, 30, 32, 33, 36 and 43, giving the number of the plate, the Julian Date, and the observation derived from photometer readings. There are fewer plates listed in the second section of Table III for the stars with numbers 19 to 43 since on some of the poorer quality plates none of these stars could be measured.

Table IV gives for these variables the maximum, minimum and mean magnitudes, the epoch of maximum (chosen as the nearest maximum just before J.D. 2438200 in the 1963 series of observations), and the period, followed by remarks when pertinent.

The light curves of these twenty variables, in order of decreasing length of period, are shown in figures 2 and 3. The points are the computed weighted means of all observations at intervals in phase of 0.04 of the period of the star. Observations with colons in Table III have been assigned half weight. A filled circle represents at least three good observations, but averages about ten such. Open circles represent mean points derived from observations which are few in number or of low weight.

Of this first group of stars, three are Cepheids with periods longer than one day. Sixteen are type *ab* RR Lyrae stars with periods between 0.48 and 0.68 days, and one is a type *c* with period 0.36 days. A period change is noticeable only for Var. 1, the Cepheid with longest period in the cluster, 18.730 days, whose period seems to be steadily shortening at the rate of $\beta = 14 \times 10^{-7}$ days/day.

In figure 2 two light curves are given for this star to illustrate graphically the change in period from an earlier to a later interval. In the case of this star, the figure shows many open circles which do not represent uncertainty in the magnitudes, but rather fewer observations in the means because of the division of material.

Joy (1949) studied spectroscopically variables 1, 2, 7, and 17 in this cluster. For Var. 1, his classification from two spectrograms was G2 and G0, with an average radial velocity of −115 km/sec, indicating cluster membership.

Variable 2, with period 2.79468 days, is the type of short period Cepheid in clusters mentioned by Joy and C. Payne Gaposchkin (1954). Joy gives the spectrum from one plate as F8, and the radial velocity as −129 km/sec.

Variable 7 seems to be a typical W Virginis star with period 13.596

TABLE III

OBSERVATIONS OF VARIABLE STARS IN NGC 6402

Plate	Julian Day*	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
103	19536.939	16.0	16.45			15.0					
2617	20725.811	15.05				16.05:					
2637	26.750	15.05	16.05	18.7	18.7	16.15	18.15	18.9	18.0	18.6	18.2
2649	48.705	15.15	15.8	18.15	18.5	15.7	18.4	18.1	18.2	18.9:	18.2
4397	1690.895	15.85	16.0			16.3			18.1:		17.2:
20544	6915.824	15.1	16.85	18.4	16.9	15.85	17.1	17.2	17.1	18.3:	17.8
20559	21.824	15.95	15.85	17.6	17.9	15.55	17.7	18.0	16.6	17.45	17.5
20571	23.785	16.9:	17.0:			15.7:					
20584	24.758	16.2	15.9			16.4	18.8:	18.2:	18.4:		
20587	.824	16.8:	15.8		18.0:	16.5:	18.2:		16.85:		
20597	25.776	16.05	16.5	17.6:		16.55		17.6:		17.9:	
20647	44.781	15.95	15.95	17.75:		15.45		17.9:	16.5	18.35:	
20675	46.742	15.5	16.9:			15.4	17.8:		17.8:	18.5:	
21377	7272.784	15.1	16.65	17.8:	18.5:	15.6	18.5	17.8	18.1	18.2	
21380	.864	15.0	16.9:	17.95:	18.9	15.5	18.1	18.4	18.6	18.05	
21386	73.788	15.0	16.4	18.4	17.7	15.55	18.0	17.7	17.7	17.8	17.9
21399	74.776	15.1	16.0:	17.45	17.5	15.4	18.05	18.3:	16.35	17.15	16.9
21406	.891	15.1	16.25	18.5	18.4	15.55	18.8	18.8:	17.4	18.1	17.7
21412	75.768	15.15	16.7	18.75	18.85	15.7	17.3	17.9:	18.45	18.95:	17.85
21416	.856	15.25	17.1	18.6	17.35	15.6	17.6	18.9	18.2	17.45	18.7
21515	306.776	14.7	16.9	18.1:	18.5	16.15	18.0:		16.6		
21538	07.799	14.85	15.85	18.0:	18.4	16.2	18.1	17.0	18.5:	18.1	17.5
21556	08.800	14.85	16.3:			15.9			17.2:		
23178	639.790	16.05	16.95	18.6	18.45	15.55	18.4	18.15	18.0	18.8	18.7
23237	58.749	15.65	16.85	18.9	19.1:	16.4	18.9	17.25	17.45	18.35	17.55

*Heliocentric

Plate	Julian Day	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
23240	27658.811	15.65	16.75:	18.55	19.0:	16.3	18.3	17.6	17.5	18.8	18.1
23252	59.760	15.1	15.95	17.9	18.7	16.5	18.5	18.4	16.5	18.55	17.15
23255	.823	15.15	15.95	18.3	18.6	16.5	18.3	18.3	16.65	18.1	17.05
23256	.840	15.05	15.85	17.7:	18.5:	16.8	17.7:	18.25:	16.5	18.4	17.5
23306	64.765	14.85	16.9	18.7	18.85	15.45	17.2	18.0	17.4	18.1	17.95
23308	.802	14.75	17.1	18.5	18.25	15.45	17.0	18.5	17.45	18.1	17.7
23399	85.730	15.15:				16.0:					
23522	713.649	16.0	16.45:			16.5:			16.9:		
23529	14.663	15.95	17.1	18.45		16.6	18.65	18.4	18.3	18.4:	17.9
23538	15.661	15.65	15.75:	17.1:		16.45		17.1:			17.2:
23600	28.630	15.85	16.8:			16.3			17.2:		
91	8015.608	15.35	16.3	18.05	17.3	16.0	17.4	17.4	18.0	17.85	18.0
92	.677	15.3	16.35			16.05			17.7:		17.6
100	16.610	14.9	16.9	17.55		15.95	17.65	18.5	17.75	17.5	16.9
101	.628	15.0	17.0	17.25	19.0:	15.9	17.2		17.8	17.6	17.1
102	.674	14.55:	17.1		17.8:	15.9	17.0:		17.55:		17.4
103	.693	14.7	17.2		17.5:	15.8	17.2		17.8:		
104	.711	14.75	17.25		17.25:	15.9	17.55:	18.3:	18.3:		18.0:
105	.732	14.7:	17.4:			16.0					17.7:
169	37.599	14.7	16.05			15.6	17.9:	18.0:	16.6		16.8
170	.617	14.5	16.1			15.6					
185	38.569	14.85	16.7	19.5:	19.5:	15.75	18.25	18.0	17.85	19.0:	18.3
186	.582	14.9	16.75	18.7	18.5	15.8	18.3		17.85		18.2
187	.608	14.75	16.7		18.6:	15.75	18.6:	17.9:			19.5:
189	.644	14.75	16.95:		17.2:	15.9					
192	.701	14.75	17.0:		17.6:	15.85			17.3:		17.3:
217	43.571	15.05	16.35		17.9	15.9	17.0	18.6:	16.45	19.0:	17.1
219	.610	15.05	16.3	18.7	17.05	16.0	16.95	19.0	16.5	18.45	16.9
223	.677	15.05	16.4	18.7	17.5	16.1	17.3	17.15	16.55	18.5	16.8
820	308.751	15.4:	16.1			15.6					

Plate	Julian Day	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
821	28308.769	15.15:	16.2			15.6					
824	.843	15.7:	16.1:			15.3					
836	09.767	15.85	17.15	17.85	17.0	15.65	17.2	17.45	17.45		17.2
837	.781	15.7	17.5:			15.5	16.7:		18.0:		
840	.835	15.75	17.05		18.05:	15.6	17.2	17.9:	17.45:		
1109	65.737	15.35	17.0	18.5:	18.3:	15.9		18.05:	18.3:	17.65:	17.3:
1110	.656	15.4	16.95		19.0:	16.1				17.1:	
1112	.706	15.45	16.9	17.2	18.0	16.0	18.35	18.45	17.4	17.5	17.9
1113	.723	15.5	17.0:	17.6:	17.35:	16.0	18.7:		16.9:	17.5:	18.1:
1115	.770	15.45	17.2	18.15:	17.5:	15.95	17.75:	18.15:	16.65	17.4:	
1123	66.631	15.6	16.05		18.15:	16.35	18.6:	17.25	17.5	18.4:	17.9:
1124	.658	15.45	15.95		19.0:	16.15	17.9:	17.9	17.8	18.6:	
1127	.729	15.55	15.85		19.0:	16.4	18.2:		19.0:	18.5:	
1226	91.592	15.05	17.0:		17.5:	15.6	18.7:		17.6:		
1227	.613	15.05	16.5		17.9:	15.65			19.0:		
1229	.678	14.9	16.5	18.2:	19.0:	15.7	16.75		18.0:		
1230	.699	15.1	16.2			15.8	16.9:		17.2:		
1240	92.603	14.55	16.15	18.2	17.85	15.8	18.8	19.0:	17.85	17.8	17.2
1241	.623	14.65	16.15	18.0	17.7:	15.9	17.95	18.05	17.5	18.1:	17.7
1244	.695	14.65	16.05	18.3:	17.65	15.95	17.85:	17.85:	17.65	18.5:	17.6
1257	93.623	14.7:				16.1:					
1267	98.587	14.8	16.25			15.65	18.05:		17.5:	17.0:	16.7
1268	.609	14.95	16.3			15.75	18.0:		17.6:	17.15:	16.9
1271	.653	14.95	16.5		17.8:	15.7	18.2:	18.0:	17.4:	18.0:	
1272	.679	15.0	16.4:		17.15	15.7	17.5:	18.9:	18.1:	17.95:	17.5
1284	99.582	14.95	17.25	17.25	18.8	15.4	18.4	18.35	16.5	18.5	18.2
1287	.630	15.05	17.05	17.35	19.0:	15.5	18.15	18.3:	16.55	18.8:	18.2
1290	.695	15.15	16.8:			15.7				16.8:	
1980	688.713	15.8	15.95			15.55	17.9:		17.6:	18.6:	17.3
1982	.759	15.85	16.05	17.2:	19.5:	15.45	18.8:	17.7:			17.5

Plate	Julian Day	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
1984	28688.822	15.7	16.25	17.9:	19.5:	15.35	18.0:	17.35:	18.0:		18.0
1994	89.720	15.75	16.7		18.6	15.45	17.9	18.6	16.55	17.1	18.6
1997	.804	15.8	16.95	18.8	18.7	15.4	18.2	18.8	17.0	17.75	17.5
2013	93.746	14.7	15.9		18.5:	16.3					
2021	95.759	14.85	16.95	18.5:	18.5:	16.15	17.7:	18.1:	16.4	17.9:	17.7
2033	96.679	14.9	16.0	17.6:	17.0:	16.05	17.45:		17.5:	17.9:	
2035	.722	14.85	15.85	18.2:	17.6	15.95	17.8	18.2	18.1	19.0:	18.7:
2037	.776	14.85	15.9	18.05:	18.0	16.1	17.7	18.6	18.0		18.1
2111	715.675	14.85	17.0:	18.3:	19.0:	15.3	17.8:		16.8	18.3:	16.75
2114	.747	15.0	16.8	18.8:	19.0:	15.35	17.8:	17.0	16.7	18.8:	17.1
2115	.770	15.0	16.6	18.8	18.8	15.4	18.2	17.05	17.15	18.6	17.4
3249	9071.710	14.75	16.2	17.4:	18.1	15.7	17.25	17.95	16.5	18.05	18.0
3252	.798	14.95	16.1	17.8	18.35	15.95	17.75	18.1	17.05	17.4	18.1
3263	72.780	14.95	17.0	18.25	18.3	16.15	17.5	18.05	18.1	18.45	18.3
3275	73.709	14.85	16.0	17.3	17.6	16.35	18.3	18.1	17.55	18.5	17.35
3278	.783	14.95	15.95	18.0	17.8	16.45	18.0	17.2	17.7	18.7	17.6
3290	76.742	15.1	15.9		19.5:	15.8	18.1	17.75	17.4	18.2	17.1
3303	77.702	15.35	16.5	17.9	18.6	15.75	17.4		17.35		17.3
3318	78.722	15.55	17.1	18.3	18.0	15.55	17.4	18.65	18.0	18.6	17.8
4209	405.920	14.6	16.55:			15.5			17.1:		17.3:
4228	06.956	14.7	16.05	18.65:	17.8:	15.2:	17.9:		18.05:	16.9:	
4584	30.738	15.1	16.9	18.4	18.6	15.8	18.2	18.05	16.6	18.7	18.1
4684	62.653	14.8	16.05	17.7	18.7:	15.4	18.05	18.3:	17.9	18.1:	
4693	63.648	14.7	16.65	19.0	19.0:	15.15	18.0		18.05	18.4	
4703	64.653	14.8	16.85	18.5:	18.8:	15.6	17.9:	17.5:	17.0	18.8:	16.8
4795	87.614	15.1	15.9	18.0:	18.6:	15.35	18.0:		17.8:	19.0:	
4807	89.702	15.6	16.85	18.8	17.35	15.4	18.8	18.1	17.9	19.0	18.3
4819	90.657	15.65	15.95	18.05	18.35	15.4	18.25	18.45	17.1	17.35	17.8
4973	519.568	14.65	16.65		18.5	15.55	18.0	18.3	16.35	18.6	17.9
5702	785.764	15.05	16.95	17.9:	17.7	15.45	17.8	17.85	17.35	17.6	17.7

Plate	Julian Day	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
5717	29786.812	15.0	15.9	17.8:	17.7:	15.25	17.65	17.4	16.85	17.3	
5728	87.784	15.3	16.55	18.3	17.75	15.4	17.35	18.3	18.05	18.85	16.75
5729	.810	15.4	16.6	18.5	18.2	15.4	17.5	18.2	18.05	18.9	17.1
5808	813.677	15.75	17.0	18.3	19.0:	15.25	17.15	18.8	18.6:	18.8	17.15
5812	.784	15.9	16.85	18.8	19.0:	15.5	18.3	17.15	18.3	18.6	
5820	14.672	15.5	15.9	19.5:	17.45	15.3	18.5	19.2:	17.4	16.9	17.7
5825	.770	15.7	16.05		18.4	15.4	17.25	18.4	17.9	17.55	17.1
5835	15.657	15.15	16.4:			15.55					
5836	.711	14.9	16.45	18.5:	17.8	15.25	18.25	18.05	16.8	18.9	17.7
5840	16.631	14.65	16.65	18.15	19.0	15.45	18.7	18.25	18.7	18.8	16.9
5843	.690	14.65	16.7	18.45	18.65	15.35	18.75	17.05	18.2	18.7	17.15
5846	.733	14.65	16.8	19.0	17.65	15.45	18.85	17.45	18.3	18.75	17.5
5848	.780	14.8	16.95	18.2	17.35	15.45	18.4	17.7	17.95	18.45	17.7
5948	41.688	15.05	16.8:	17.8	18.7	15.5	17.1	18.5	16.65	18.4	18.2
5964	42.703	15.2	15.95		18.3:	15.55	18.3:		18.5:	18.1:	
5974	43.623	15.3	16.4	17.8:	17.35	15.45	18.3	17.0	16.95	17.55	16.6
5980	.732	15.25	16.45	18.4:	17.45	15.45	18.8:	18.1:	17.9:	17.5:	17.3
6836	30169.693	15.6	16.05	18.6:	17.2:	15.35		19.0:	17.8:	18.6:	17.8:
6837	.722	15.7	16.0		17.9	15.4	18.4	18.4:	17.5:	19.0:	17.6
6838	.751	15.8	16.0		17.8	15.35	18.4	18.6:	18.8:	19.0:	16.85
6839	.789	15.65	16.05	18.4:	18.4	15.4	18.0	18.6	18.2	18.3:	16.9
6847	70.715	15.5	16.75	18.45:	17.45	15.4	18.5	18.25	17.7	18.3	17.7:
6861	71.730	15.05	17.0	18.5	18.6	15.3	18.35	17.6	16.4	18.05	17.8
6864	.797	15.0	16.9	17.65	17.95	15.5	18.4	17.7	17.0	18.3	18.0
6870	72.642	14.55	16.0	17.9	18.7	15.65	17.6	18.2	18.05	18.6	18.0:
6875	.747	14.6	16.0	18.1	18.5	15.65	17.9	18.2	18.0	17.3	17.1
6930	97.722	14.9:	15.5:			15.5:					
6938	99.705	15.35	16.8:			15.65	18.1:		18.3:		
6951	200.696	15.55:	16.0			15.7					
7923	549.662	14.9	15.8	17.75	18.35	15.35	17.8	16.8	17.5	18.7	17.5:

Plate	Julian Day	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
7927	30549.750	14.95	15.85	18.0	18.6	15.35	17.2	17.4	17.6	16.85	
7937	50.686	14.95	16.4	18.5	18.05	15.65	18.05	18.45	16.55	18.25	17.6
7940	.727	15.05	16.45	18.85	18.15	15.35	17.9	18.55	16.55	18.4	17.8
7943	.806	15.05	16.45	18.15	18.85	15.45	17.5	17.65	17.35	18.2	17.9
7949	52.679	15.0	15.9	18.6	17.1	15.6	17.9	17.4	17.4	17.8	18.6:
7955	53.644	15.1	16.65	18.0	18.55	15.55	18.0	18.5	18.15	16.8	17.35
7961	.720	15.05	16.75	18.05	18.3	15.65	18.0	17.7	16.35	17.35	17.8
7964	.779	14.95	16.65	17.85	17.05	15.65	17.95	17.25	17.0	17.4	17.9
7974	54.656	15.05	16.6	18.9	18.6	15.9	17.55	18.35	18.05	18.75	18.2
7979	.739	15.0	16.35	17.5	18.25	15.75	17.55	18.1	17.5	16.95	17.1
8014	56.686	15.3	16.85	17.55	18.0	16.3	17.25	17.05	17.9	18.35	17.25
8020	.748	15.35	16.85	17.35	18.5	16.5	17.2	17.6	16.25	18.45	18.05
8117	86.604	14.8	16.05	18.4	18.25	15.9	18.2	17.3	17.7	17.1	17.0
8895	899.685	16.15	16.2	18.35	18.0	15.95	18.25	18.2	17.7	18.25	17.6
8902	.754	16.3	16.3	18.6	18.55	15.85	18.55	18.55	17.9	18.4	18.2
8907	.811	16.35	16.35	18.7	19.0	15.85	18.4	18.5	18.1	19.0	17.9:
8919	900.675	16.05	16.9	17.7	17.45	15.65	18.4	17.3	16.55	17.95	17.55
8926	.766	16.0	17.1	17.75	17.9	15.7	18.4	17.85	17.15	18.15	17.3
8930	.813	16.0	17.05:	17.8:	17.55:	15.65	17.95:	17.7:	17.4:	18.1:	17.0
9002	32.617	15.75	15.9	17.95	18.4	15.45	18.25	18.4	17.85	18.8	17.3
9003	.627	15.6	15.95	18.35	18.65	15.35	18.4	18.6	17.95	18.55	17.6
9005	.652	15.65	15.8	18.25	18.35	15.45	18.3	18.1	17.15	18.65	17.35
9006	.661	15.7	15.85	18.25	18.25	15.55	18.15	18.25	16.75	18.3	17.4
9008	.685	15.7	15.8	18.3	18.35	15.55	18.45	18.3	16.4	18.65	17.65
9009	.694	15.6	15.9	18.3	18.55	15.45	18.65	18.55	16.4	18.65	17.55
9011	.714	15.8	15.85	18.7	18.75	15.45	18.7	18.2	16.4	18.85	17.95
9012	.724	15.75	15.8	18.45	18.35	15.5	18.4	18.3	16.65	18.65	17.75
9013	.734	15.75	15.85	18.45	18.7	15.5	18.35	18.7	16.75	18.95	18.05
9022	33.600	15.95	16.5	18.45	17.4	15.55	18.55	18.0	17.65	18.2	18.2
9023	.610	15.8	16.5	18.1	17.4	15.6	18.0	17.9	17.6	17.9	18.2

Plate	Julian Day	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
9025	30933.635	15.9	16.55	19.0	17.5	15.7	18.5	18.15	18.1	18.25	18.1
9027	.658	15.9	16.5	18.65	17.6	15.65	18.15	18.25	18.15	18.25	18.05
9030	.687	15.9	16.5	18.8	18.15	15.65	18.25	18.5	18.1	18.65	18.25
9033	.717	15.85	16.6	18.35	18.0	15.6	18.0	18.25	18.05	18.35	17.4
10134	1259.731	14.8	16.0		18.9	15.6	19.0:	18.1:	16.7	17.05	18.0
12045	969.756	15.95	16.1			16.65					
12051	.817	15.8	16.15	18.5:	17.7:	16.4	17.8:	17.7:	17.25:	17.6:	16.55
12070	70.779	15.55:	16.85:			16.05		18.3:			
12143	77.736	15.15	16.0	18.75:	18.45	15.6	17.85	17.95:	16.2	18.25	17.3
12260	99.693	15.35	15.95	17.9	19.2:	15.9	17.6	17.8	17.35	18.9	18.4
12345	2005.706	16.0	15.85	18.5	18.6	15.5	17.45	17.55	17.45	18.35	18.2
12349	.758	16.2	15.8	18.45	18.55	15.55	17.7	17.55	17.5	18.5	18.35
12361	06.641	16.1	16.45	17.85	18.4	15.75	18.7	18.85	18.0	17.95	18.05
12364	.677	16.05	16.45	17.8	18.65	15.65	17.9	18.35	17.8	18.15	18.05
12370	.747	16.05	16.7	18.15	18.6	15.6	17.05	18.5	16.4	18.4	17.95
13424	355.697	15.45	16.25	17.25	18.2	15.45	18.2	18.7	17.2	17.2	18.1
13431	.756	15.2	16.15	17.75	18.35	15.45	18.15	18.15	17.55	17.75	18.15
13436	.828	15.55	16.1	18.0:	18.25	15.35	18.1:		17.8:	18.5:	
13445	56.657	15.8	16.85	18.3	17.65	15.4	17.8	17.25	17.1	18.9	17.25
13448	.710	15.6	17.0	18.4	17.95	15.45	18.05	17.65	16.2	18.8	17.45
13460	57.655	15.95	15.75	17.55	17.55	15.55	17.8	18.6	17.9	18.55	18.05
13464	.701	15.75	15.45	17.9	17.25	15.5	18.25	18.75	17.9	18.95	18.7
13488	60.659	16.15	15.95	18.4:	18.5	15.7	18.45	17.6	17.9	17.05	18.15:
13492	.723	16.1	15.85	18.9	18.75	15.55	17.4	17.15	17.8	17.5	18.2
13497	.793	16.15	16.0	18.5	18.7	15.75	17.45	17.35	17.8	17.9	17.2
14580	740.637	14.6	15.75	17.35	18.5	15.9	17.45	17.95	17.1	17.9	17.85
14584	.683	14.7	15.85	17.7	18.6	15.75	17.55	18.2	17.45	18.1	17.95
14591	.762	14.65	15.85	17.95	17.05	15.7	17.6	18.6	17.6	18.45	18.15
14604	41.638	14.6	16.35	18.5	18.5	15.95	17.8	17.25	17.75	17.15	17.15
14609	.692	14.8	16.45	18.5	18.9	15.75	17.3	17.6	16.35	17.7	17.4

Plate	Julian Day	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
14624	32742.621	14.95	17.0	17.7	18.5	16.15	18.3	18.55	18.0	18.65	18.1
14629	.673	14.95	16.95	17.9	18.7	16.25	18.4	18.65	17.9	18.3	18.35
14638	.779	14.95	16.75	18.25	18.55	16.1	17.25	17.15	17.6	17.5	17.6
14756	70.616	15.95	16.75	17.7	18.5	16.4	18.1	18.2	18.05	17.2	17.85
14764	.697	16.05	16.8	17.8	18.6	16.45	18.3	18.2	16.5	17.85	18.05
21395	4929.638	15.65	16.25	17.4	18.6	15.5	17.6	18.1	17.65	17.7	17.05:
21402	.752	15.85	16.35	18.05	18.2	15.6	17.8	18.4	16.6	17.95	17.45
21426	31.665	15.2	15.8	17.95	18.55	16.05		18.25	17.25	18.8	17.3:
21431	.719	15.0	15.95	17.65	17.85	16.25	17.55	16.9	17.5	19.0	18.5:
22343	5273.697	14.95	16.5	18.3	19.0	16.45	17.05	18.55	16.8	17.25	18.3:
22348	.765	14.9	16.55	18.2	18.4	16.45	17.8	18.4	17.1	17.8	18.05
22363	74.691	14.95	16.85	18.9	18.25	16.1	17.95:	18.3	18.0	18.8	18.0:
22371	.796	15.0	16.95	17.7:	19.0:	16.25	17.1:	18.6:	16.9	16.9	18.7
22380	75.701	14.95	16.0	17.9	17.9	16.1	18.05	17.45	17.6	18.45	17.6
22385	.814	15.1	16.05	18.2:	18.6:	16.0	16.8	18.0	17.5:	18.8	17.7:
22516	309.632	14.85	16.05	18.7	18.4	15.45	18.5	17.15	17.75	18.9	18.2
22521	.679	14.8	16.15	18.45	17.25	15.4	18.0	17.4	17.65	18.55	18.25
22540	10.624	14.8	17.05	17.65	18.6	15.55	18.5	18.45	17.05	18.15	17.85
23295	685.610	14.9	16.75	18.6	17.0	15.9	18.05	18.05	17.5	18.05	18.05:
23315	87.621	14.8	16.65	18.65	18.55	15.55	17.75	17.35	16.7	17.7	17.05
23332	88.633	14.95	16.2	17.95	18.6	15.35	17.3	19.0	18.1	16.75	17.8
23909	6044.661	15.0	16.2	17.95	18.6	15.5	17.95	18.35	17.65	18.4	18.25:
23913	.697	15.05	16.3	17.2	18.15	15.45	17.15	18.2	17.65	18.5	17.8
B1691	49.660	15.7:				16.6:					
B1705	51.660	15.9:				16.2:					
B1715	52.669	15.55:	15.9:			16.15:		18.0:	17.6:		
B1722	53.640	16.2:				15.8:					
B1742	67.646	15.8			17.55:	15.4			18.25:		
B1752	68.663	15.65:				15.5:					
B1765	70.652	15.95	16.7:		17.8:	15.5	17.2:	17.9:	17.45:	17.5:	

Plate	Julian Day	No. 1	No. 2	No. 4	No. 5	No. 7	No. 9	No. 10	No. 11	No. 15	No. 16
B1782	36072.686	15.75	16.15:	17.4:	17.9:	15.7	17.8:	18.5:	16.35	18.15:	
B1789	73.640	15.4				15.6		17.1:	17.5:	18.1:	
24773	750.679	14.6	16.05	17.95	18.3	15.35	17.25	18.05	17.35	17.8	
24779	.739	14.8	16.0	16.65	18.4:	15.35	17.9	18.45	17.8	18.2	17.05
24785	52.640	14.85	16.95	17.75	18.45	15.55	17.95	18.5	16.3	18.9	17.6
24793	.733	14.9	17.05	17.7	18.7	15.45	17.3	17.0	16.95	17.35	17.85
24808	53.648	14.95	15.9	18.45	17.9	15.65	18.05	18.4	17.6	18.55	18.2:
24813	.762	14.9	15.85	18.4	18.3	15.6	17.75	18.3	17.95	18.55	17.1
26203	7849.648	16.1	15.85	18.15	18.65	15.25	18.65	17.45	16.25	19.0:	18.15:
26204	.661	16.1	15.9	18.05	18.05	15.35	18.0	17.6	16.3	18.3:	18.0
26205	.682	16.15	16.0	18.2	18.35	15.25	18.3	17.55	16.4	18.4	18.3
26207	.707	16.2	16.15	18.5	18.2	15.3	18.3	18.35	16.65	18.6	18.2
26210	.750	16.0	16.15	18.2	18.3	15.3	17.6	18.0	17.15	18.0	18.1:
26222	50.672	16.05	16.65	18.5	17.55	15.4	18.05	17.95	17.6	18.3	17.9:
26225	.700	16.0	16.8	18.1	17.8	15.4	18.35	18.25	17.85	18.15:	18.5:
26227	.733	15.9	16.65	17.8	18.5	15.35	17.85	17.2	17.7	19.0:	18.15:
26829	8198.704	14.95	15.8	17.75	18.5	16.1	18.05	18.5	17.8	18.65	
26835	.763	15.15	15.65	17.75	18.5	16.15	18.2	17.15	17.55	18.25	
26837	.783	15.1	15.8	18.0	18.1	16.15	18.45	16.9	17.75	18.6	18.2:
26851	99.690	15.15	16.4	18.9	17.6	16.1	18.05	18.6	16.9	18.75	18.1
26853	.712	15.15	16.25	18.2	17.45	15.9	18.15	18.2	17.05	18.4	18.1
26857	.754	15.2	16.5	18.7	17.25:	15.85	18.35	18.5	17.1	18.35	17.8
27559	587.693	14.85	16.1	18.4:	17.65	15.45	18.0	18.8:	16.8	17.3	

Plate	Julian Day	No. 19	No. 22	No. 23	No. 24	No. 25	No. 30	No. 32	No. 33	No. 36	No. 43
2637	20726.750	18.5	18.4	17.8	19.0:		18.9:	18.3	18.0	18.3	18.1
2649	48.705	19.0:	18.15	18.7:	16.85		16.9	17.0	18.2:	17.5	17.7
4397	1690.895				18.1:		19.0:	17.45			
20544	6915.824	18.4	18.1:	18.65	17.9	18.3	17.0	18.65:	17.8:	18.3	18.2:
20559	21.824	18.05	18.5	18.7	18.6	18.7	17.6	18.4	17.4	17.25	18.4

Plate	Julian Day	No. 19	No. 22	No. 23	No. 24	No. 25	No. 30	No. 32	No. 33	No. 36	No. 43
20571	26923.785						17.9:				
20584	24.758		17.8:	17.45:			18.0:				18.2:
20587	.824		17.3:	17.0:							18.0:
20597	25.776			17.7:	17.7:		18.6:				17.7:
20647	44.781		18.2:	18.05:	19.0:		17.8	18.2:		16.45:	17.75:
20675	46.742			18.0:	18.3:		18.3:				18.0:
21377	7272.784	18.0	17.8:	18.3:	19.0:	18.25:	17.7	18.5:		18.0:	17.8:
21380	.864	17.3	18.55:	18.8	18.8	18.05:	17.9	18.55:	18.1		18.55:
21386	73.788	18.6	17.45	17.55	18.25	17.5	17.45	17.5	18.0	17.8	17.65
21399	74.776	18.8	18.7	18.8	19.0:	18.0	17.4	18.25	18.7	18.35	18.05
21406	.891	19.5:	18.5	17.7	18.8	18.8:	17.4	18.3		17.4	18.3:
21412	75.768	18.3	17.9	18.7	18.9	18.0:	18.15	17.9	18.15	18.25	17.85
21416	.856	19.0:	18.0	18.9	19.2:	17.6	16.9	18.2	18.4	18.5	17.55
21515	306.776		18.1:		18.3		18.1:	18.3:		17.25	17.7:
21538	07.799	17.6		18.8:	17.5:		17.9:		18.2:	18.1	17.75:
21556	08.800						18.5:				
23178	639.790	18.65	18.0	18.6	18.45	17.7	18.2	17.7	17.8:	18.0	18.1
23237	58.749	17.9	17.2	18.4:	17.65	18.5	18.3	17.1	18.3	17.75	17.2
23240	.811	18.15	17.65	16.95	18.15	18.55	18.6	17.45	18.6	17.85	17.6
23252	59.760	17.3	18.55	18.5	17.3	18.3	18.15	18.1	18.1	18.25	17.4
23255	.823	17.9	18.7	18.7	17.8	18.05	17.8:	18.05	17.9:	18.2:	17.85
23256	.840	18.6		18.2:	17.9:	17.9:	18.8	17.9:	18.8:	17.9:	17.9:
23306	64.765	17.95	18.0	18.55	18.55	17.9	16.95	17.6	17.6	17.4	17.85
23308	.802	17.9		18.3	19.0:	17.9	17.15	17.45	17.65	17.35	17.8
23522	713.649						18.0:				
23529	14.663	18.7	18.15:	17.65	18.4	18.6:	18.1	18.1	17.6	18.6	18.0
23538	15.661			18.0:			17.6			16.95:	17.35:
23600	28.630		19.0:	18.0:							
91	8015.608	17.6	17.35	16.95	18.2	17.95	18.1	17.0	17.8	18.15:	17.55
92	.677	17.8:									17.5:

Plate	Julian Day	No. 19	No. 22	No. 23	No. 24	No. 25	No. 30	No. 32	No. 33	No. 36	No. 43
100	28016.610	16.95	18.1	18.3	18.5	18.3	18.1	17.8	17.0	17.3	17.35
101	.628	17.25	17.8	18.6:	19.0:	18.2	17.9	17.8	17.2	17.55	17.45
102	.674	17.6:					18.3			17.2:	
103	.693	17.8:		17.65:			17.9:				
104	.711			17.55:	18.5:		18.0:	18.5:		17.7:	
105	.732	17.7:		17.15:							
169	37.599						17.9:			17.4:	17.5:
170	.617						18.5:				
185	38.569	18.4	17.6	19.0:	19.5:		18.5	17.2	18.5	18.3	17.35
186	.582	18.0	17.75	18.3:	18.5	18.05	18.4	17.3	18.0:	17.8	17.65
187	.608	17.7	17.6:				17.9	17.1:		18.0:	17.1:
189	.644	17.6					17.9				17.3:
192	.701						18.0				17.4:
217	43.571	18.3	19.0:	19.0:	18.6:		16.9	18.8:	18.7	17.75:	18.8:
219	.610	18.2	19.0	19.0:	18.7	19.0:	17.2	17.9	17.8:	19.0	17.6
223	.677	18.5	17.65	19.0:	18.15:	17.65	17.6	17.5:		17.2:	16.5:
836	309.767	17.4	17.85:				17.7				16.75:
837	.781						18.4:				
840	.835		17.75:				18.1:	17.75:			16.9:
1109	65.637	18.5:		17.9:			17.4:		17.6:		16.9:
1110	.656				17.9:		17.5:				17.5:
1112	.706	18.1	18.35	18.55	17.25	19.0:	16.8	17.9:	17.8:	18.7:	17.3
1113	.723		19.0:	19.0:	17.0:		16.7:	19.0:		18.5:	17.95:
1115	.770		17.5:	17.6:	17.3:		17.7:			17.75:	17.45:
1123	66.631	18.1:	18.15:	19.0:	19.5:	17.4	18.3:	17.9:		17.9	17.0:
1124	.658	19.0:	17.7	18.8:	18.8:	17.9:		17.55		17.4:	17.05
1127	.729			18.0:	17.8:		17.2:				17.2:
1226	91.592	17.5:	18.2:		19.0:		17.8			17.8:	17.4:
1227	.613	18.0:		19.0:	19.0:		18.0:			17.45:	16.95:
1229	.678		17.8:				17.9:				17.05:

Plate	Julian Day	No. 19	No. 22	No. 23	No. 24	No. 25	No. 30	No. 32	No. 33	No. 36	No. 43
1230	28391.699				18.5:						17.2:
1240	92.603	17.8	18.1	18.3:	18.5	18.05	17.8	17.85	17.9:	18.3	17.65
1241	.623	17.7	18.0:	18.4:	18.7:		17.9	18.0:	18.5:		
1244	.695	18.4	17.35:	19.0:	18.6		17.6	17.2:	18.2:	17.85	17.9
1267	98.587	17.5	17.3:	18.05:	17.65:	19.0:	18.0	17.4:	17.3	19.0:	17.15:
1268	.609	17.4	17.05:	18.5	18.5:	17.9	17.9:	17.3:	17.2	18.1:	17.75
1271	.653	18.0:		18.6:		17.6:	18.4:				17.35:
1272	.679	18.0	17.9	19.0:	18.9:	17.35	18.0	17.65	17.7:	18.1:	18.0
1284	99.582	18.6	18.7	18.0:	17.5	18.25	18.1	18.15		18.35:	17.3
1287	.630	17.7	17.8	17.95	17.5:		17.9	18.0:		17.3	17.65
1980	688.713	18.0:	17.8:	18.4:	17.8:		19.5:	17.5:		18.8:	18.6:
1982	.759	18.0:	17.5:	19.0:	18.8:	17.2:	18.0:				17.6:
1984	.822	18.0:	18.0	19.0	19.5:	17.65	19.0:	17.9:		17.6:	17.9
1994	89.720	18.3	19.5:	18.8	17.8	19.0:	17.9	18.9	18.1:	18.3	
1997	.804	18.5	17.4	18.8	18.55	17.6	18.3	18.4	18.5	17.6	17.75
2013	93.746	17.3:	16.85:		18.3:		17.0:				16.85:
2021	95.759	18.0:	17.5:	18.5	18.2:		18.5:	17.15:	17.4:		17.55:
2033	96.679	18.5:		17.2:			18.3:			17.2:	17.4:
2035	.722	17.9	18.8	17.55	18.2	18.0	18.0	18.0	17.5:	17.7	17.5:
2037	.776	18.0	18.5	17.7	19.0:	18.05	18.0	17.8	17.35	17.85	17.95
2111	715.675	17.8	18.3:	18.2:	17.5:		17.0		18.2:	17.75:	16.95:
2114	.747	18.7:	18.5:	18.5	19.0:	18.2:	17.6	18.1		17.8	17.7:
2115	.770	18.3	18.45	18.2	18.0	18.05:	17.9	18.05	17.9:	17.9	17.95
3249	9071.710	17.5	17.5	17.3	18.35	18.25	17.9	17.15	17.7	18.0	17.65
3252	.798	18.5:	18.0	17.8	17.8	17.6	18.1	17.65	17.9	17.85	17.7
3263	72.780	18.6	18.35	17.7	17.25	18.15	18.1	18.0	18.3	18.15	18.1
3275	73.709	18.5	18.3	18.5	19.0	17.9	17.8	17.95	18.2	17.75	17.7
3278	.783	18.3	18.15	18.7	18.7	18.35	18.2	17.7	18.3:	18.10	18.0
3290	76.742	18.6:	17.45:	17.45	19.5:	18.1:	16.75			18.3	17.05:
3303	77.702	18.6	17.4	18.2	18.5	18.0	18.3	17.4:	17.5	17.6	18.7

Plate	Julian Day	No. 19	No. 22	No. 23	No. 24	No. 25	No. 30	No. 32	No. 33	No. 36	No. 43
3318	29078.722	18.8:	17.8	18.25	18.2	18.0	18.6	18.0	17.7	17.9	18.0
4209	405.920			18.3:			17.3:				18.0:
4228	406.956	17.2:	17.9:	17.9:			17.1:				18.2:
4584	30.738	18.1	18.5	17.15	18.4	17.7:	18.0	18.05	18.1	18.6	17.85
4684	62.653	17.3	17.2	17.85	18.5:	18.0:	17.6:		17.7:	18.1:	18.0:
4693	63.648	18.7	18.4	19.0:	18.65	18.5	17.6	17.75	17.1	18.0	18.2:
4703	64.653	19.0:	18.3:	19.0:	18.9:	17.9	17.15	17.4		18.5:	17.8:
4795	87.614		18.6:	17.0:	19.0:		17.1	17.3:		19.0:	18.8:
4807	89.702		18.9	18.7	18.5	18.7:	16.85	17.8	17.7	18.9:	18.0
4819	90.657	18.15	17.35	18.35	18.4	17.95	18.6	18.3	17.9:	17.65	17.7
4973	519.568	18.6	17.7	18.9	18.25	18.25	18.6	18.2	18.3	18.5	17.75
5702	785.764	18.1	17.9	17.7	18.0:	17.75:	17.1	17.55	17.0	17.6	17.1
5717	86.812	18.0:		18.5:	18.9:	18.0:	16.8:	17.3:		17.25:	17.1:
5728	87.784	18.2	17.4	18.2	18.1	17.75	17.05	17.95	17.95	18.25	18.2
5729	.810	17.5	17.55	18.5	17.9	18.05	16.8	18.2	18.3	18.3	18.2
5808	813.677	18.6	19.0	18.15	17.2	18.4:	18.2	17.45	17.7	18.9	18.0
5812	.784	18.5	18.4	18.7	18.2	18.0	17.9	17.9	18.4		17.9
5820	14.672	17.6	17.7	17.4	17.1	18.9	17.9	18.15	17.65	17.6	18.5
5825	.770	18.5	17.7	17.65	17.6	17.75	18.2	17.9	17.9	17.9	18.0
5835	15.657						17.0:				
5836	.711	17.2	18.7	17.4	17.5	18.5	18.0	18.05	18.0:	18.25	17.8
5840	16.631	18.3	18.05	18.7	18.9	18.0	17.15	18.55	18.2:	17.65	17.2
5843	.690	18.5	17.65	19.1:	18.75	17.7	16.95	18.05	18.2:	17.6	17.45
5846	.733	17.25	17.95	18.85	18.25	18.1	17.4	18.5	18.6	17.85	18.1
5848	.780	17.25	18.0	18.15	17.15	18.1	17.7	18.15	18.3:	17.7	18.05
5948	41.688	18.7	17.45	17.05	17.75	18.2	18.3	17.65	17.5:	17.6:	17.4
5964	42.703				19.5:		18.5:				17.4:
5974	43.623	18.1	17.6	18.6	18.2	18.2	18.3	18.05	18.1:	18.5	18.3
5980	.732	18.3	18.0:	18.0:	18.8:	18.0:	18.1:	17.6:	17.1	18.2:	17.4:
6836	30169.693	18.5:	18.2:	18.6:	19.0:		18.2:	17.4:	17.8:	17.6:	18.2:

Plate	Julian Day	No. 19	No. 22	No. 23	No. 24	No. 25	No. 30	No. 32	No. 33	No. 36	No. 43
6837	30169.722	19.0:	19.0:	18.8	19.0:	18.0	18.8:	17.8	17.5:	18.1	17.4
6838	.751	18.7	18.0	18.0		18.2:	16.9	17.35	18.2:		18.0
6839	.789	17.1	17.6	17.2	17.0	17.9	16.9	16.95	17.9:	18.4:	17.0
6847	70.715	18.8:	18.2:	18.7	18.9	18.45	18.6	17.65	17.7:	18.05	18.0
6861	71.730	18.5	18.1	18.4	18.5	18.15	18.15	17.1	18.1:	18.3	17.75
6864	.797	18.2	18.35	18.6	18.85	18.4	18.4	17.4	18.2:	18.5	18.25
6870	72.642	17.9	18.15	17.85	18.4	17.85	17.75	17.7		17.5	
6875	.747	18.4	17.95	18.15	18.6:	17.85	18.0	17.9	18.1:	17.8	18.15
6938	99.705			17.6:	18.5:	17.6:	16.9			17.1:	18.3:
7923	549.662	17.75	17.95	18.2	18.7	17.9	17.2	17.0	18.25:	17.5	17.7
7927	.750	18.2	18.1	17.4	18.2	18.05	18.1	17.6	17.65:	17.8	17.7
7937	50.686	16.9	17.45	18.4	18.4	17.55	16.75	17.65	18.0:	18.25	17.3
7940	.727	17.3	17.8	18.15	18.3	17.7	17.25	17.9	17.7	18.3	17.5
7943	.806	18.0	18.0	18.55	18.7	18.25	17.85	17.6	17.35	18.6	17.8
7949	52.679	18.9:	17.55	17.45	18.6	18.35	18.4	17.8	17.3	18.05	18.0
7955	53.644	18.5	18.3	17.05	18.1	17.85	18.25	17.3	17.2	17.25	17.75
7961	.720	18.6	18.2	17.05	18.25	18.2	18.25	17.45	17.4	17.6	17.45
7964	.779	18.4:	18.8	17.5	18.0:	18.1:	18.3	17.7	17.7:	17.85	17.15
7974	54.656	18.05	17.7	18.4	17.9		18.05	18.05	17.3	18.4	17.8
7979	.739	18.5	17.9	17.0	18.0:	17.85	18.35	17.8	17.6:	17.95	18.1
8014	56.686	16.9	17.65	18.05	18.0	18.5	17.55	17.85	17.6:	18.1	17.65
8020	.748	17.45	18.25	18.4	18.0	17.85	17.85	17.3	18.15:	18.4	18.05
8117	86.604	18.5	18.3	18.05	18.25	18.15	17.9	17.55	18.15	18.15	17.8
8895	899.685	18.25	17.7	18.7	17.9	18.2	17.9	17.85	17.0	18.1	17.15
8902	.754	18.5	18.3	18.7	17.2	17.9	18.2	18.3	17.5	18.15	17.2
8907	.811	18.3	17.9	18.65	17.9	18.0	18.4	17.35	17.75	18.5	17.5
8919	900.675	18.6	18.35	17.9	18.55	18.25	17.3	17.7	17.3	18.7	17.5
8926	.766	18.6	19.0	18.1	16.9	18.8:	17.7	17.5	17.85	17.25	17.1
8930	.813		17.95:	18.1:	17.6:		18.0:	17.35:		17.2:	17.45:
9002	32.617	17.85	18.6	17.55	18.3	17.65	17.75	17.6	18.05:	17.25	17.15

Plate	Julian Day	No. 19	No. 22	No 23	No. 24	No 25	No 30	No. 32	No. 33	No. 36	No. 43
9003	30932.627	17.7	18.3	17.8	17.9	17.85	17.1	17.4	18.2:	17.2	17.1
9005	.652	16.95	18.6	18.3	18.3	17.45	16.9	17.15		17.3	17.65
9006	.661	17.05	18.6	18.25	18.35	17.25	17.2	17.15	17.65:	17.1	17.35
9008	.685	17.15	18.65	18.2	18.55	17.6	17.3	17.05	17.85	17.3	17.65
9009	.694	17.1	18.75	18.15	18.55	17.6	17.15	17.05	17.95	17.6	17.55
9011	.714	17.45	19.1:	18.6	18.6	17.65	17.6	17.55	17.7	17.4	17.7
9012	.724	17.6	18.55	18.4	18.5	17.65	17.7	17.5	17.55	17.65	17.75
9013	.734	17.7	18.2	18.3	18.25	17.8	17.5	17.35	17.25	17.45	17.85
9022	33.600	18.4	18.4	18.2	17.55	18.35	18.4	17.6	18.3	17.85	17.35
9023	.610	18.6	17.9	17.85	17.4	18.35	18.55	17.5	18.1:	17.8	17.05
9025	.635	18.4	17.85	17.55	17.8	18.35	18.15	17.85	18.0:	18.3	16.85
9027	.658	18.3	17.2	16.9	17.9	18.0	18.25	17.6	18.0	18.3	16.95
9030	.687	18.6	17.2	17.05	18.05	17.95	17.6	17.8	17.6	18.3	17.3
9033	.717	17.7	17.35	17.15	18.3	17.75	16.9	17.75	17.1	18.2	17.55
10134	1259.731	18.4	18.3:	18.1:	18.6:	17.7:	17.5:	18.8:	17.7:	18.5	16.75:
12045	969.756						17.6:				
12051	.817	18.8:	17.4:	17.3:	17.8:	17.3:	18.1	16.8:	17.45	17.3:	16.7:
12070	70.779						17.6:				
12143	77.736	17.8	18.45	17.65	18.6	17.35	17.8	17.25	17.7:	17.8	17.45
12260	99.693	18.3	17.8	17.3	18.5	17.7	18.2	18.25	17.85	18.0	17.7
12345	2005.706	18.1	17.6	17.35		18.2	18.1	18.0	17.75	18.95	17.8
12349	.758	18.8	18.45	17.2	18.6	17.7	18.3	18.05	17.8	18.3	17.55
12361	06.641	18.05	18.7	18.45	17.35	18.3	18.0	17.6	18.35	17.3	18.35
12364	.677	18.1	18.2	18.55	17.7	18.1	18.1	17.55	18.0	17.45	18.35
12370	.747	18.5	17.2	18.45	18.15	18.3	18.3	17.75	17.7	17.85	18.05
13424	355.697	18.5	17.15	18.35	18.45	17.6	18.7	17.6	17.75:	17.25	18.3
13431	.756	17.1	17.7	18.6	18.75	17.75	18.5	17.6	17.55	17.25	18.3
13436	.828	17.5	17.9:	18.4	18.7:	18.4:	17.0	17.75	17.6	17.4	18.25
13445	56.657	18.7	18.15	17.85	18.15	18.15	18.4	17.7	18.15:	17.9	18.25
13448	.710	18.6	18.05	18.1	18.3	17.55	18.7	17.75	17.45	18.15	18.15

Plate	Julian Day	No. 19	No. 22	No. 23	No. 24	No. 25	No. 30	No. 32	No. 33	No. 36	No. 43
13460	32357.655	18.7	17.4	17.5	18.55	18.4	18.3	17.65	17.8:	18.1	18.0
13464	.701	18.4	17.6	17.75	18.45	18.7	18.5	17.75	17.35	17.5	17.9
13488	60.659	17.2	19.0	18.7	17.2	17.45	17.05	17.75		17.3	18.1
13492	.723	17.4	18.75	18.5	17.6	17.55	17.6	17.0	17.6:	17.9	17.8
13497	.793	18.1	18.85	18.9	18.35	17.7	17.5	17.4	17.7:	17.8	18.35
14580	740.637	18.0	18.05	17.95	18.45	17.9	17.7	17.15	17.45	18.1	17.85
14584	.683	18.3	17.45	18.3	17.05	18.1	18.0	17.5	16.85	18.15	18.25
14591	.762	18.4	17.4	18.7	17.4	18.3	18.3	17.5	17.6	17.6	18.35
14604	41.638	17.7	18.2	17.7	18.45	17.5	17.6	17.9	17.0	17.35	18.0
14609	.692	18.0	18.85	18.75	18.25	17.8	17.95	17.9	17.05	17.45	17.95
14624	42.621	17.35	18.1	17.15	18.45	17.9	16.9	17.35	16.95	17.95	17.55
14629	.673	17.1	17.3	17.3	18.75	17.7	17.4	17.45	17.2	18.2	17.5
14638	.779	18.15	17.8	18.6	16.75	17.8	18.1	17.85	18.25	18.2	18.0
14756	70.616	18.0	18.2	18.3	18.4	18.0	18.15	18.0	18.21	17.6	18.15
14764	.697	18.25	18.45	18.0	18.6	17.95	18.5	16.95	18.05	16.9	17.1
21395	4929.638	18.8	17.55	18.5	18.15	17.55	18.5:	17.4		17.5	17.2
21402	.752	17.55	18.1	18.55	18.0	17.8	17.1	17.45	17.9:	17.95	18.0
21426	31.665	18.3	18.25	17.9	18.4	18.7	18.4	17.6		18.0	18.55
21431	.719	18.7:	17.05:	17.85	18.3	18.05	18.3	17.3	18.1:	17.95	17.8
22343	5273.697	18.5	18.3	18.3	17.5	17.8	18.45	17.85	18.25:	18.2	18.3
22348	.765	18.65	18.05	18.3	18.0	17.7	17.3	17.8	18.35:	17.4	18.2
22363	74.691	17.9	17.35	18.2	17.0	18.05	18.6:	17.2	18.1:	17.3	18.2
22371	.796	18.8:	18.1:	18.9	18.5:	17.8:	18.7	17.65:		17.8:	18.5
22380	75.701	17.55	18.2	17.5	17.55	18.05	18.2	17.8	18.1:	18.4	17.6
22385	.814		17.0:	17.9:	17.3:	17.9:	18.2	17.4:		17.2	17.9:
22516	309.632	18.05	18.6	18.65	17.95	18.25	17.5	18.1	17.9:	18.15	18.0
22521	.679	18.2	18.3	18.5	18.15	18.25	17.65	17.95	17.8:	17.75	17.75
22540	10.624	17.7	17.4	18.4	17.6	17.5	17.3	17.2	17.85:	17.5	17.2
23295	685.610	18.2	18.2	17.7	19.1	17.7	18.35	17.65	17.9:	17.5	17.95:
23315	87.621	17.1	18.5	17.65	17.9	18.0	18.35	18.05	17.6	17.75	18.0

Plate	Julian Day	No. 19	No. 22	No. 23	No. 24	No. 25	No. 30	No. 32	No. 33	No. 36	No. 43
23332	88.633	18.35	17.9	18.5	18.0	17.75	18.6:	17.3	17.4:	18.15	18.35
23909	6044.661	18.7	17.9	18.5	17.1	17.65	17.15	17.2	18.2:	17.35	17.35
23913	.697	18.05	17.75	18.1	17.15	17.4	17.45	16.9	17.9:	16.9	17.45
B1715	52.669						16.9:				18.0:
B1742	67.646		17.65:	17.0:	17.3:	18.1:	17.2:	16.35:			17.9:
B1765	70.652		18.9:	17.9:	17.0:	17.6:	18.0:	17.65:		17.15:	17.35:
B1782	72.686		18.2:	17.4:	18.2:			17.5:	17.6:	17.7:	18.15:
24773	750.679	17.6		19.0	17.2	17.8	17.95	17.6	17.05:	17.45	17.2
24779	.739	18.2	18.45	18.7	17.55	18.05	18.5	17.7	17.8:	17.85	18.0
24785	52.640	18.5	18.25	17.35	19.0:	17.9	17.85	17.55	17.15	17.15	17.05
24793	.733	18.3	18.25	18.05	17.9	17.55	18.15	17.9	17.7	17.6	17.45
24808	53.648	18.9	17.6	17.55	18.55	18.1	17.2	18.0	17.4:	17.85	17.25
24813	.762	18.4	17.95	17.55	18.15	17.8	18.05	17.45	17.85:	18.2	17.8
26203	7849.648	17.45	17.5	17.75	19.5:	17.45	18.3		18.35:	17.3	18.2
26204	.661	17.85	17.6	17.75	19.5:	17.75	18.6		18.25	17.65	18.1
26205	.682	17.7	17.5	17.9	18.65	17.75	18.3	17.95	17.95	17.45	18.1
26207	.707	17.8	18.2:	18.2	18.6	17.75	18.6	18.0	17.8:	17.65	18.35
26210	.750	18.35	17.8	18.3	17.5	18.1	18.4	17.85	17.25	17.9	18.3
26222	50.672	16.85	17.9	17.05	18.8	17.4	18.6	17.25	17.6:	18.0	17.9
26225	.700	17.4	18.25	17.35	18.35	17.45	18.4	17.5	17.8:	18.15	
26227	.733	17.8	18.55	17.4	19.5:	17.75	18.5	17.25	17.85:	17.95	18.15
26829	8198.704		17.3	17.0	18.55	18.45:	17.2	17.75		17.0	17.85
26835	.763	17.7	17.85	17.7	18.45	17.55	17.5	18.0	17.2:	17.2	18.1
26837	.783	17.7:	17.7	18.55	18.75	17.85	17.3	18.0	17.9:	17.05	18.5
26851	99.690	18.6	18.55	18.35	17.8	18.55	18.3	17.15	17.8:	18.65	18.35
26853	.712	18.7	18.3	17.45	17.55	18.2	17.1	17.7	17.6:	17.9	18.05
26857	.754	18.3	18.2	16.95	18.8	18.0	17.0	17.95	17.6	17.95	18.3
27559	587.693	18.5:	17.95:	18.2	18.6	17.7	17.4	18.0:		17.85	17.85

NOTES TO TABLE III

Plates 103-4397 taken by F. G. Pease and H. Shapley with Mt. Wilson 60-inch reflector.

Plates 20544-23600 taken by H. Sawyer Hogg with Dominion Astrophysical Observatory, 72-inch reflector.

Plates 4209 and 4228 taken by H. Sawyer Hogg with 36-inch reflector, Steward Observatory, University of Arizona.

Plates B 1691 to B 1789 taken by various observers with 19-inch David Dunlap reflector.

All other plates taken by H. Sawyer Hogg with 74-inch David Dunlap reflector.

TABLE IV

Var.	Max.	Magnitude Min.	Mean	Epoch of Maximum	Period days
1	14.65	16.1	15.35	38191.8	18.730
2	15.8	17.0	16.4	38198.58	2.79468
4	17.2	18.6	17.9	38199.23	0.651313
5	17.1	18.7	17.9	38199.61	0.548796
7	15.4	16.5	15.95	38189.56	13.596
9	17.0	18.4	17.7	38199.47	0.538831
10	17.1	18.5	17.8	38199.34	0.585914
11	16.4	18.0	17.2	38199.59	0.604417
15	16.9	18.6	17.75	38199.51	0.557727
16	16.8	18.2	17.5	38199.40	0.600617
19	17.0	18.6	17.8	38199.34	0.545671
22	17.3	18.5	17.9	38199.23	0.655916
23	17.1	18.5	17.8	38199.72	0.552342
24	17.0	18.7	17.85	38199.64	0.519901
25	17.65	18.4	18.0	38199.48	0.360707
30	16.9	18.3	17.6	38199.72	0.534226
32	17.0	18.1	17.55	38199.55	0.655975
33	17.3	18.3	17.8	38199.59	0.479946
36	17.2	18.3	17.75	38199.33	0.677990
43	17.0	18.2	17.6	38199.46	0.521747

REMARKS TO TABLE IV

Var. 1 The period seems to be steadily shortening rapidly, and may be expressed as $P = 18^{d}.730 - 14 \times 10^{-7} (T - T_0)$, where $T_0 = 2438200.00$, over the interval of 52 years represented by the observations.

Var. 11 This variable, on the outskirts of the cluster, is more than half a magnitude brighter than the average of the other cluster-type variables.

Var. 25 The period of 0.360350 days satisfied our observations almost as well, and it is difficult to determine which is the true period.

Var. 33 The accuracy of measures for this star is less than average because it is a blended double.

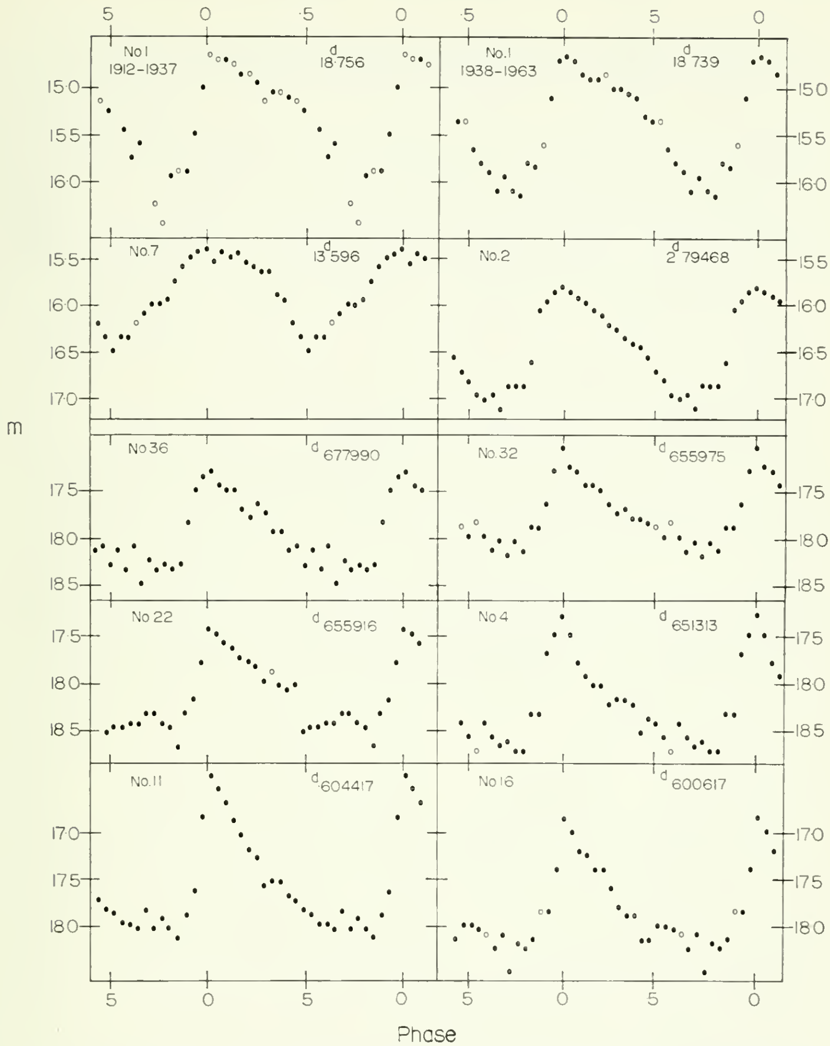

FIG. 2—Mean light curves for the nine stars of longest period in this group of 20. Two curves are given for Var. 1 to show the change in period.

days, very similar to Var. 29 in Omega Centauri (Martin 1938), whose period is comparable. From two plates, Joy gives spectral types of F5 and G2e3, with an average radial velocity of −136 km/sec.

Our comments on the total picture of the variables in this cluster will be reserved till the final paper. The second paper of this series is

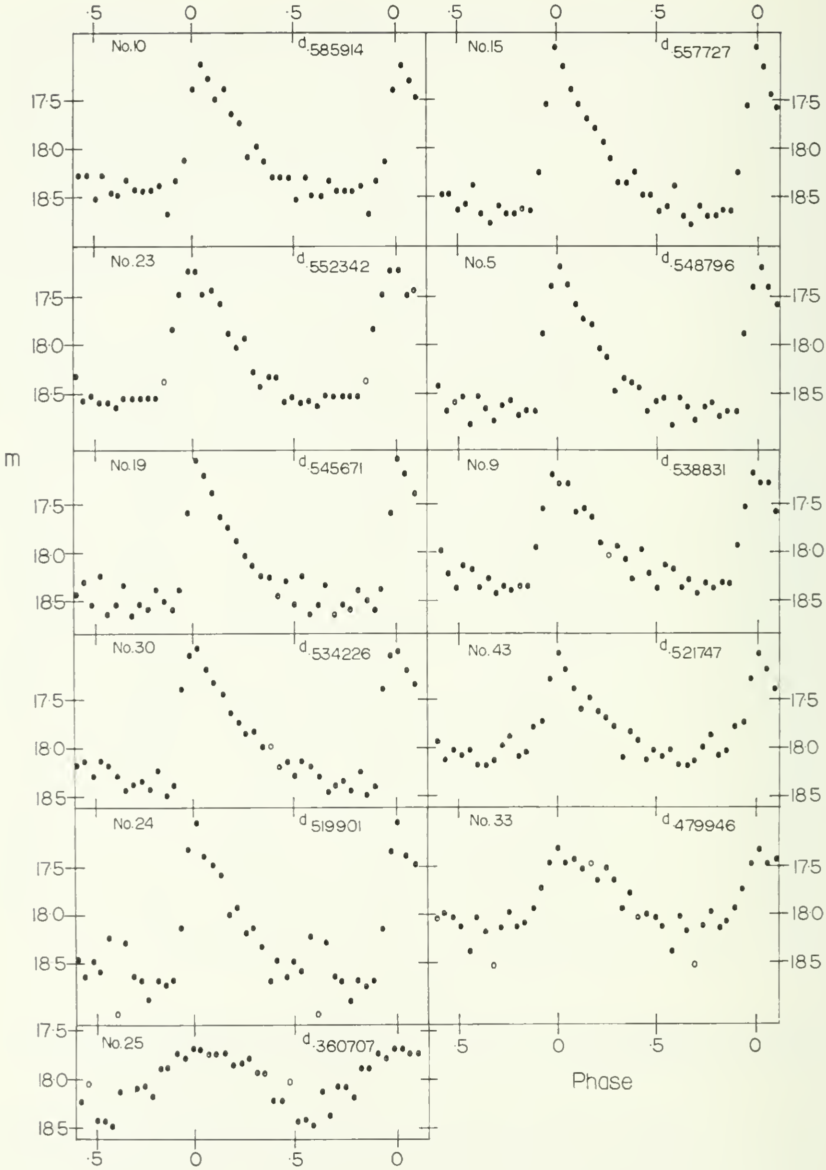

FIG. 3—Mean light curves for 11 variables, arranged by decreasing length of period.

in preparation. A summary of the results for the first forty periods determined in this cluster was presented at the Michigan meetings of the American Astronomical Society in August 1965 (Sawyer Hogg and Wehlau 1965).

It is a pleasure to express our appreciation to the National Research Council of Canada for generous support of this prcgram, and to many observers at the David Dunlap Observatory who assisted with the telescopic part of the program, especially the late Dr. Frank S. Hogg and Mr. G. F. Longworth.

April 27, 1966

References

Joy, A. H. 1949, *Ap. J.*, vol. 110, p. 105.

Martin, W. Chr. 1938, *Leiden Ann.*, vol. 17, pt. 2.

Payne-Gaposchkin, C. 1954, "Variable Stars and Galactic Structure," p. 37. University of London.

Sawyer, H. B. 1937, *R.A.S.C. Jour.*, vol. 31, pp. 57–59.

Sawyer, H. B. 1938, *Dom. Ap. Obs. Pub.*, vol. VII, no. 5.

Sawyer Hogg, H. and Wehlau, A. 1964, *A.J.*, vol. 69, no. 2, p. 141; *R.A.S.C. Jour.*, vol. 58, no. 4, pp. 163–166; *D.D.O. Comm.*, no. 97.

Stebbins, J., Whitford, A. E., and Johnson, H. L. 1950, *Ap. J.*, vol. 112, p. 475.

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ABSOLUTE ENERGY DISTRIBUTIONS FOR STARS OF SPECTRAL TYPES F, G AND K

GRETCHEN L. HAGEN
AND
SIDNEY VAN DEN BERGH

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ABSOLUTE ENERGY DISTRIBUTIONS FOR STARS OF SPECTRAL TYPES F, G AND K

By Gretchen L. Hagen and Sidney van den Bergh

Abstract

Absolute energy distributions over the range $3600 \leqslant \lambda \leqslant 4500$ A. are given for 154 stars of spectral types F, G and K. The spectral energy distributions of these stars are compared to those of globular clusters and galaxies. Globular clusters are found to resemble metal-poor high-velocity stars. The spectral energy distributions of the nuclei of M31 and M32 are obviously composite. M32 appears to be either dwarf-enriched or moderately metal-poor.

The observations reported in this paper were obtained with a spectrum scanner which is located at the Cassegrain focus of the 74-inch telescope. The dispersing element of this instrument is a Bausch and Lomb replica reflection grating with 600 grooves per millimetre. The centre of its blaze is at λ3750 in the second order, which was the order used. A refrigerated 1P21 photomultiplier was employed as a light detector.

Tracings of a large number of stars covering the range $3600 \leqslant \lambda \leqslant 4500$ A. were available from previous observing programmes (van den Bergh 1963, 1966, and van den Bergh and Sackmann 1965). All tracings were made at an effective resolution (spectral purity) of 20 A.

Observations of early-type standard stars (Oke 1960) were used to transform the observed deflections to absolute energy units. The mean wave-length-dependence of atmospheric extinction was taken from van den Bergh and Henry (1962).

It should be emphasized that the observations used for the present programme were originally made to measure narrow-band parameters. Such measurements do not require nights of the highest photometric quality. The accuracy of the results is therefore lower than that which could have been obtained in a programme devoted exclusively to studies of the spectral energy distributions of stars. The present study includes only those stars for which at least four tracings obtained during two or more nights were available. The average *internal* mean error of the combined data for each star is found to be 0.02 mag. at λ4000, 0.03 mag. at λ3800 and 0.04 mag. at λ3600. Within the accuracy of the data these errors are found to be independent of apparent magnitude and spectral type.

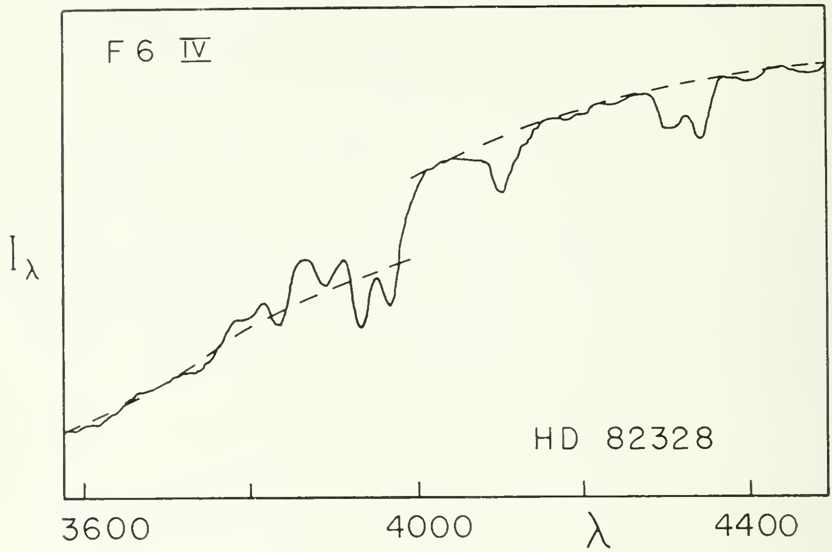

FIG. 1—Spectrum scan at 20 A. resolution of the F6 IV star θ UMa. The dashed line indicates the adopted schematic continuum.

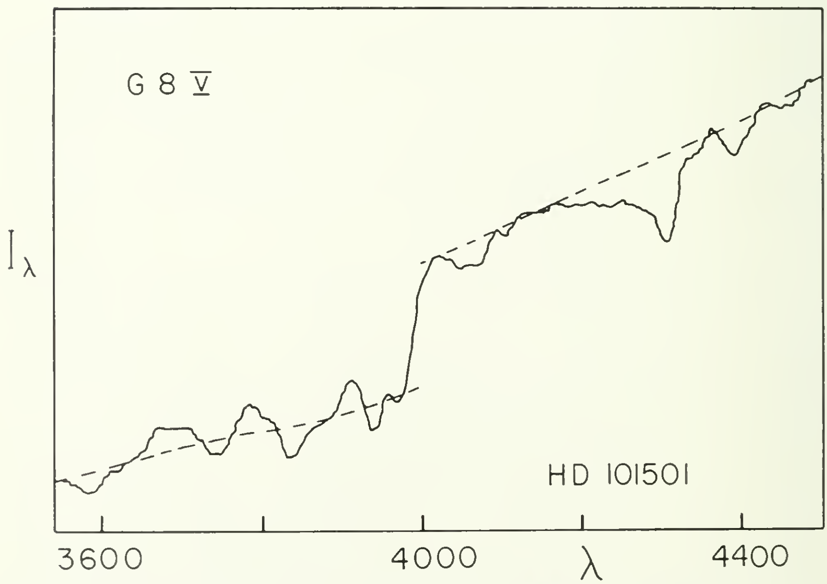

FIG. 2—Spectrum scan at 20 A. resolution of the G8 V star 61 UMa. The dashed line indicates the adopted schematic continuum.

Typical tracings of stars are shown in figures 1 and 2 where the dashed line represents the adopted schematic continuum. Except near the G-band and the Hγ and Hδ lines the adopted schematic continuum in the region $\lambda > 4000$ A. coincides with the observed pseudo-continuum. For $\lambda < 4000$ A. the adopted schematic continuum represents the strongly smoothed mean of the actually observed pseudo-continuum. The only reason for drawing the schematic continuum in this particular fashion is that it yields consistent and easily reproducible results.

For all of the programme stars the observed values of $m(1/\lambda)$, at 100 A. intervals along the schematic continuum, are given in Table I. In the table n is the number of tracings on which the tabulated values of $m(1/\lambda)$ are based. Stars whose H.D. numbers are marked with an asterisk have spectral types which were determined by Mr. Peter Hagen using 74-inch spectra having dispersions of 33, 40 or 66 A./mm. The spectral types for H.D.208110 and H.D.22211 are uncertain.* Figures 3 and 4 show sample plots of the schematic spectral energy distributions of stars of different spectral types and luminosity classes.

The data in Table I may be used to form monochromatic colour indices. For example a monochromatic colour index $C(41\text{–}45)$ can be defined by the equation

$$C(41\text{–}45) = m(1/\lambda)(4100) - m(1/\lambda)(4500).$$

Figure 5 shows a plot of the observations of the colour index $C(41\text{–}45)$ versus $C(38\text{–}45)$ for main sequence stars (dots) and subgiants (crosses). Binaries and metal-poor stars with ultraviolet excess $\delta(U\text{-}B) > 0.10$ have not been plotted. Figure 6 shows that such metal-poor stars (dots) lie above the monochromatic colour-colour curve for stars of normal metal abundance.

Using the wave-length dependence of interstellar reddening given by Whitford (1958) and the globular cluster reddening values given by van den Bergh (1967) it is possible to obtain the monochromatic intrinsic colour indices of globular clusters (van den Bergh and Henry

*H.D.208110. Peter Hagen classifies this star as G0 IV, III with the following comments: (1) the star rotates very slowly. (2) the standards available at D.D.O. in this region are not complete. (3) Sr II (λ4077) is very sharp and indicates a much higher luminosity than given by other criteria. (4) Ca II (λ4227) gives an earlier spectral class than do the H lines.

H.D.22211. The spectral type is uncertain because all the lines appear to be rotationally broadened to an extent which may be inconsistent with the classification of G0 III.

1962). In figure 6 the intrinsic colours so obtained are plotted as crosses. The figure shows that globular clusters fall in the same region of the monochromatic two-colour diagram as do high-velocity stars.

Monochromatic intrinsic colours of the nuclear regions of M31 and M32 were derived by assuming a reddening $E_{B-V} = 0.12$. The positions of M31 and M32 in figure 6 suggest that their spectral energy

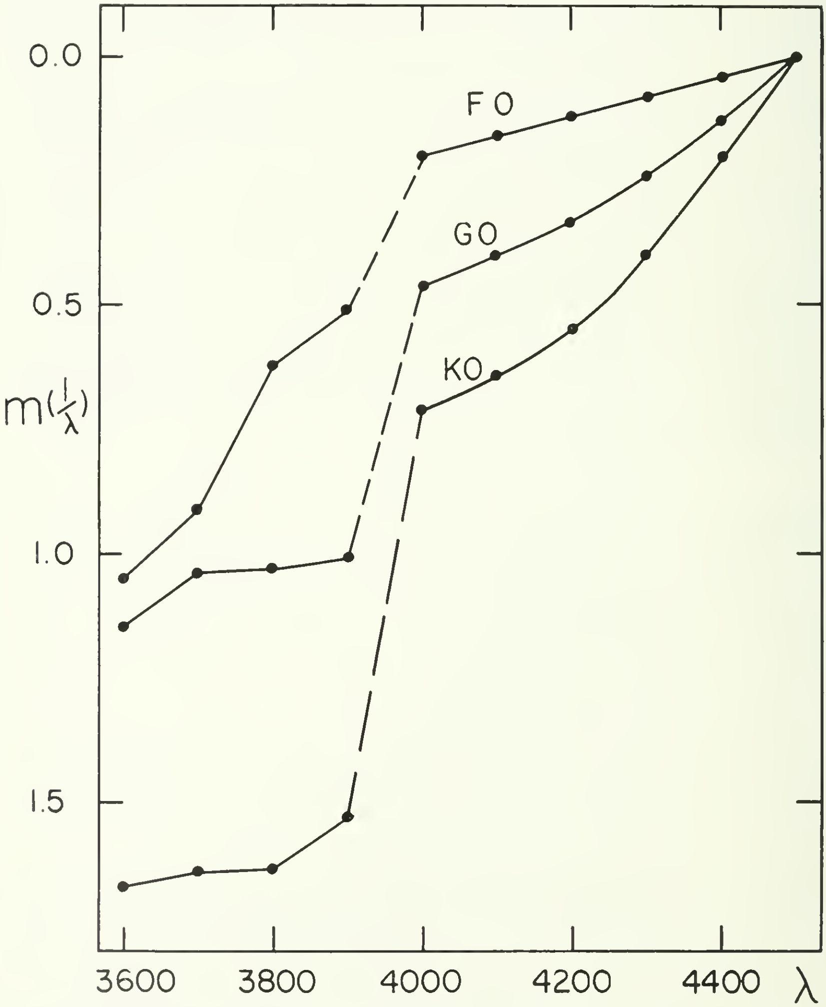

Fig. 3—Comparison of the absolute energy distributions of the following main sequence stars: H.D.58946 (F0), H.D.34411 (G0) and H.D.75732 (K0).

distributions are composite. Table II shows that the combination G0 V + K2 III (with the G star contributing one third of the light at λ4500) gives a reasonably good representation of the spectral energy distribution of the nucleus of M31 over the range $3600 < \lambda < 4500$ A. It should be emphasized that this type of synthesis is not unique. Nevertheless the data suggest that stars near the main-sequence turn-off

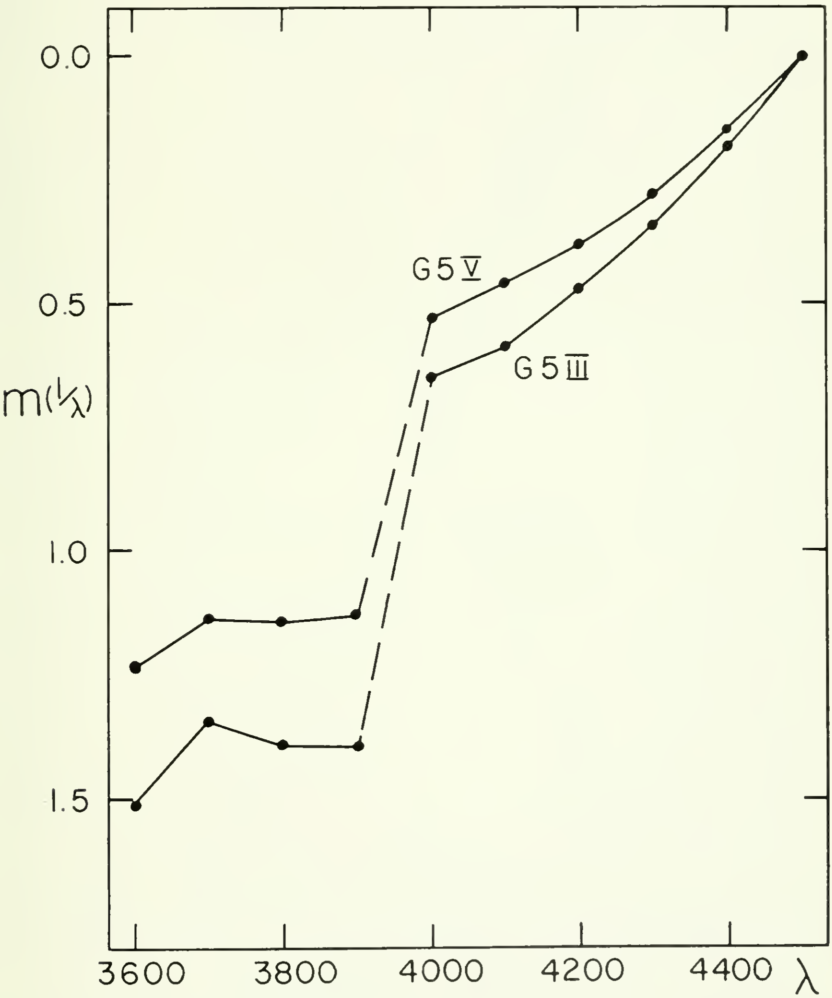

FIG. 4—Comparison of the absolute energy distributions of H.D.20630 (G5 V) and H.D.27022 (G5 III).

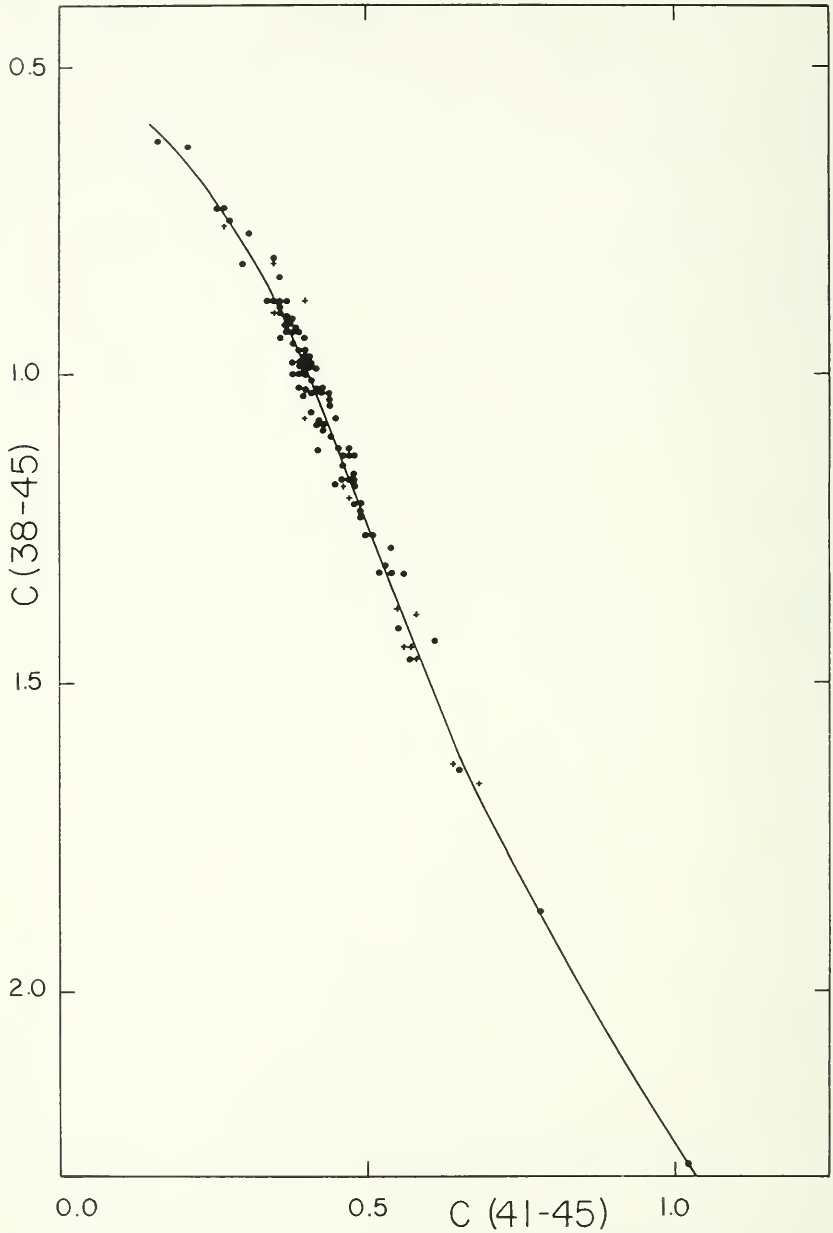

Fig. 5—Monochromatic colour-colour plot for main sequence stars (*dots*) and subgiants (*crosses*). Metal-poor stars with $\delta(U\text{-}B) > 0.10$ have not been plotted.

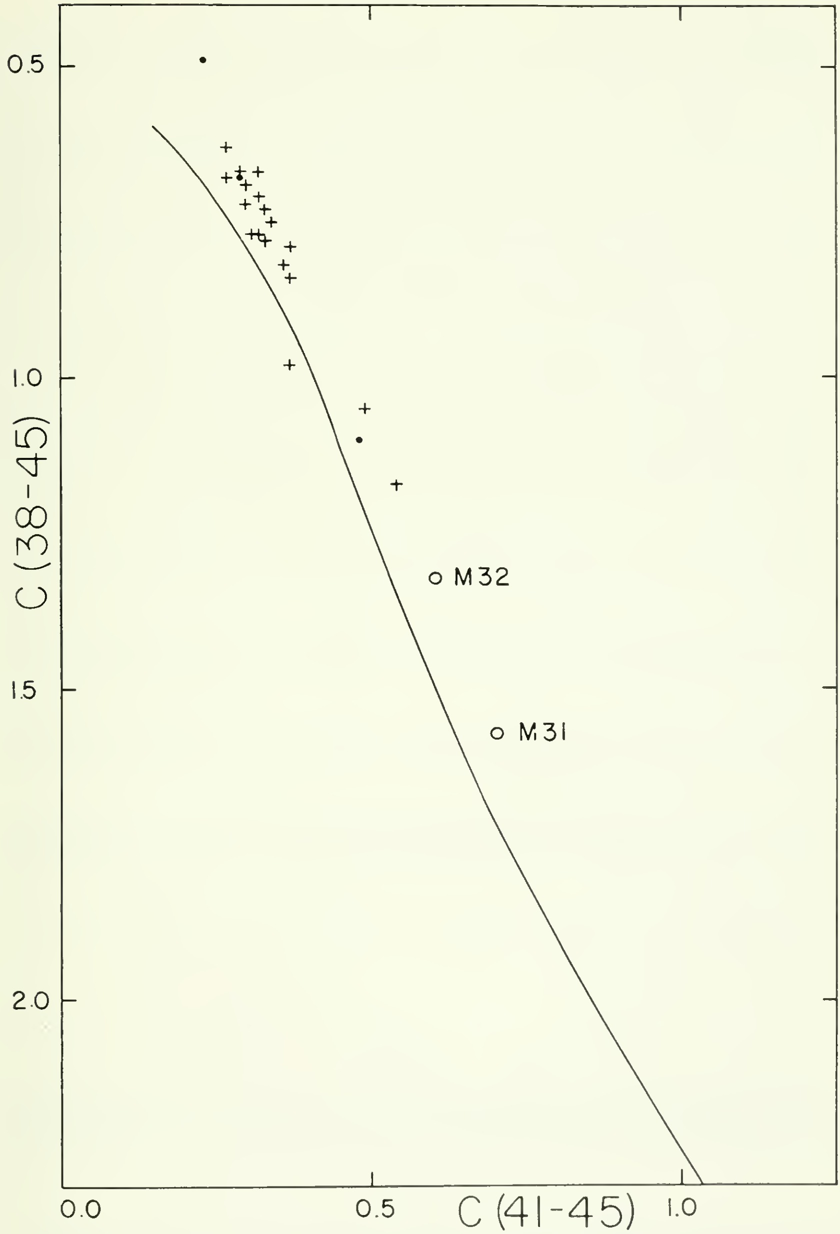

FIG. 6—The figure shows the positions of metal-poor high-velocity stars (*dots*), globular clusters (*crosses*) and of the nuclei of M31 and M32 relative to the intrinsic colour-colour relation of figure 5. The data for M31, M32 and the globular clusters have been corrected for interstellar reddening.

TABLE 1

H.D.	Sp.	n	4500	4400	4300	4200	4100	4000	3900	3800	3700	3600
26	K0 IIIp	4	0.00	0.26	0.49	0.66	0.80	0.89	1.54	1.57	1.61	1.62
166	K0 V	8	0.00	0.17	0.33	0.44	0.52	0.59	1.26	1.32	1.28	1.35
3651	K0 V	4	0.00	0.22	0.39	0.55	0.65	0.74	1.57	1.64	1.62	1.64
4614	G0 V	6	0.00	0.12	0.22	0.30	0.37	0.42	0.89	0.91	0.95	1.06
6582	G5 VI	10	0.00	0.14	0.27	0.36	0.44	0.52	1.06	1.04	1.02	1.10
8036AB	G8 III	8	0.00	0.12	0.22	0.31	0.36	0.42	0.96	1.14	1.27	1.44
8262	G3 V	4	0.00	0.13	0.25	0.34	0.41	0.48	1.00	1.01	1.01	1.10
9270	G8 III	7	0.00	0.19	0.36	0.54	0.66	0.72	1.58	1.62	1.61	1.66
9407	G6 V	4	0.00	0.16	0.30	0.41	0.48	0.56	1.18	1.21	1.21	1.29
9826	F8 IV, V	8	0.00	0.11	0.21	0.28	0.35	0.42	0.88	0.90	0.98	1.15
10307	G2 V	12	0.00	0.13	0.24	0.32	0.39	0.45	0.99	1.00	1.00	1.10
10697*	G5 V	4	0.00	0.16	0.30	0.42	0.51	0.58	1.22	1.26	1.26	1.39
11592	F5 V	7	0.00	0.08	0.15	0.21	0.27	0.32	0.68	0.73	0.86	0.99
12235*	G0 IV	5	0.00	0.14	0.27	0.37	0.46	0.51	1.06	1.12	1.17	1.31
13974	G0 V (SB)	11	0.00	0.12	0.22	0.31	0.38	0.44	0.90	0.92	0.96	1.04
16141	G5 IV	5	0.00	0.16	0.28	0.36	0.47	0.55	1.14	1.20	1.17	1.32
16397*	G1 V	5	0.00	0.11	0.20	0.27	0.35	0.41	0.86	0.86	0.86	1.00
16895	F7 V	5	0.00	0.10	0.18	0.24	0.30	0.35	0.77	0.82	0.89	1.05
17584	F2 III	4	0.00	0.06	0.10	0.14	0.20	0.23	0.59	0.70	1.05	1.29
18757	G4 V	6	0.00	0.14	0.26	0.34	0.42	0.49	1.09	1.12	1.11	1.21
18925	G8 III: + A3:	4	0.00	0.13	0.23	0.32	0.38	0.42	0.94	1.19	1.36	1.60
19373	G0 V	8	0.00	0.13	0.23	0.32	0.38	0.45	0.99	1.00	1.02	1.16
19445	sdF7	10	0.00	0.07	0.13	0.18	0.23	0.27	0.47	0.49	0.55	0.70
20630	G5 V	9	0.00	0.15	0.28	0.38	0.46	0.53	1.13	1.14	1.13	1.23
21770	F4 III	5	0.00	0.06	0.11	0.17	0.22	0.26	0.59	0.67	0.91	1.11
22211*	G0 III	4	0.00	0.12	0.22	0.32	0.38	0.48	0.93	0.98	1.08	1.28
22879*	G0 VI	4	0.00	0.11	0.20	0.26	0.32	0.36	0.76	0.75	0.78	0.90
23089/90	A + G2 III	6	0.00	0.14	0.25	0.35	0.44	0.50	0.85	0.99	1.22	1.46
25680	dG1	4	0.00	0.15	0.27	0.35	0.43	0.49	1.06	1.08	1.06	1.18
27022	G5 III	4	0.00	0.18	0.34	0.47	0.59	0.65	1.39	1.39	1.34	1.51

H.D.	Sp.	n	4500	4400	4300	4200	4100	4000	3900	3800	3700	3600
28068	G1 V	6	0.00	0.15	0.27	0.35	0.44	0.52	1.05	1.05	1.04	1.12
28099	dG2	6	0.00	0.16	0.29	0.38	0.48	0.55	1.12	1.13	1.13	1.21
28305	K0 III	4	0.00	0.23	0.44	0.63	0.77	0.85	1.81	1.93	1.92	1.92
28344	G2 V	6	0.00	0.13	0.25	0.33	0.43	0.50	1.02	1.02	1.04	1.15
30455	G2 V (SB)	6	0.00	0.13	0.24	0.32	0.40	0.46	0.97	0.98	1.01	1.08
30649	G1 V–VI	7	0.00	0.12	0.22	0.29	0.37	0.44	0.86	0.88	0.88	0.99
32923AB*	G1 IV	7	0.00	0.16	0.27	0.37	0.44	0.51	1.06	1.08	1.09	1.21
33021	dG2	4	0.00	0.13	0.24	0.32	0.40	0.48	0.98	1.00	1.02	1.13
34411	G0 V	10	0.00	0.13	0.24	0.33	0.40	0.46	1.01	1.03	1.04	1.15
38858	dG4	4	0.00	0.17	0.26	0.35	0.44	0.50	1.02	1.02	1.00	1.09
39587	G0 V	5	0.00	0.14	0.24	0.33	0.40	0.45	0.96	0.96	0.96	1.01
39881	dG0	4	0.00	0.15	0.26	0.35	0.44	0.50	1.07	1.10	1.11	1.19
42618	G4 V	5	0.00	0.17	0.25	0.36	0.45	0.51	1.05	1.07	1.06	1.10
42807	G6 V	4	0.00	0.17	0.28	0.38	0.47	0.55	1.10	1.13	1.13	1.19
48682	G0 V	5	0.00	0.14	0.23	0.31	0.38	0.44	0.92	0.95	0.99	1.10
50692	dG0	6	0.00	0.15	0.23	0.31	0.38	0.44	0.93	0.93	0.94	1.06
52711	dG2	4	0.00	0.16	0.24	0.32	0.40	0.43	0.94	0.94	0.96	1.06
55575	G0 V	4	0.00	0.11	0.21	0.29	0.35	0.42	0.88	0.88	0.89	1.03
58946	F0 V	8	0.00	0.04	0.08	0.12	0.16	0.20	0.51	0.62	0.91	1.05
60803	F8	5	0.00	0.16	0.24	0.32	0.40	0.45	0.96	0.98	1.01	1.12
62613	dG8	4	0.00	0.18	0.31	0.44	0.54	0.64	1.27	1.32	1.29	1.35
65583	G8 V	4	0.00	0.16	0.27	0.38	0.47	0.56	1.15	1.12	1.08	1.13
66242*	F7 V	4	0.00	0.15	0.25	0.35	0.43	0.50	1.03	1.02	1.08	1.24
70110	G0	4	0.00	0.17	0.25	0.34	0.43	0.50	1.00	1.02	1.04	1.18
72905	G0 V	8	0.00	0.13	0.24	0.33	0.40	0.48	0.99	1.00	1.02	1.14
74874AB	G0 III	4	0.00	0.15	0.25	0.34	0.42	0.47	1.03	1.15	1.26	1.42
75732*	K0 IV	8	0.00	0.20	0.40	0.55	0.64	0.71	1.53	1.63	1.64	1.67
76151	dG3	6	0.00	0.18	0.29	0.39	0.48	0.55	1.13	1.17	1.15	1.24
77236	K2 III	4	0.00	0.26	0.53	0.76	0.90	1.02	1.97	1.99	1.90	2.11
79096	K0 V	6	0.00	0.16	0.30	0.40	0.49	0.57	1.24	1.23	1.19	1.22

H.D.	Sp.	n	4500	4400	4300	4200	4100	4000	3900	3800	3700	3600
81192*	G8 IV	4	0.00	0.19	0.36	0.51	0.63	0.74	1.49	1.47	1.42	1.52
81809	G2 V (SB)	6	0.00	0.16	0.26	0.36	0.44	0.51	1.06	1.03	1.03	1.16
82328	F6 IV	4	0.00	0.08	0.15	0.21	0.27	0.33	0.70	0.76	0.92	1.09
82885	G8 IV–V	6	0.00	0.20	0.37	0.49	0.58	0.62	1.34	1.39	1.36	1.46
84737	G2 V	4	0.00	0.14	0.25	0.33	0.40	0.48	1.01	1.03	1.05	1.18
86728	G4 V	10	0.00	0.16	0.28	0.38	0.46	0.54	1.16	1.17	1.14	1.24
89025	F0 III	4	0.00	0.06	0.08	0.13	0.17	0.18	0.50	0.60	1.16	1.41
90508	G1 V	6	0.00	0.13	0.24	0.34	0.40	0.47	0.96	0.97	0.98	1.10
95128	G0 V	13	0.00	0.12	0.24	0.33	0.39	0.46	1.00	1.02	1.03	1.16
97334	G0 V	8	0.00	0.13	0.24	0.34	0.40	0.46	0.98	0.99	1.00	1.11
97561AB	G7 IV	4	0.00	0.18	0.33	0.46	0.55	0.61	1.21	1.26	1.28	1.35
99491*	G8 IV	6	0.00	0.18	0.37	0.51	0.61	0.67	1.34	1.43	1.42	1.56
101501	G8 V	12	0.00	0.16	0.30	0.40	0.48	0.56	1.20	1.21	1.19	1.26
102870	F8 V	5	0.00	0.12	0.22	0.29	0.36	0.42	0.92	0.94	1.00	1.16
103095	G8 VI	7	0.00	0.13	0.27	0.38	0.48	0.58	1.11	1.10	1.08	1.14
109358	G0 V	10	0.00	0.11	0.22	0.30	0.36	0.42	0.90	0.90	0.92	1.04
110897	G0 V	8	0.00	0.11	0.20	0.27	0.34	0.39	0.80	0.81	0.85	0.97
111395	G7 V	4	0.00	0.14	0.29	0.40	0.48	0.56	1.15	1.18	1.16	1.26
113226	G9 II–III	4	0.00	0.18	0.36	0.55	0.70	0.75	1.65	1.72	1.62	1.85
114174	G5 IV	4	0.00	0.14	0.28	0.38	0.46	0.52	1.06	1.08	1.08	1.17
114710	G0 V	7	0.00	0.12	0.22	0.29	0.36	0.40	0.89	0.89	0.93	1.04
115043	G1 V	8	0.00	0.13	0.24	0.31	0.39	0.46	0.96	0.96	0.98	1.09
115383	G0 V	4	0.00	0.12	0.22	0.30	0.37	0.41	0.90	0.92	0.97	1.08
117176	G5 V	10	0.00	0.16	0.29	0.39	0.47	0.55	1.17	1.17	1.16	1.27
121370	G0 IV (SB)	4	0.00	0.13	0.23	0.32	0.40	0.45	1.01	1.07	1.10	1.28
122548	K0	4	0.00	0.24	0.48	0.66	0.79	0.87	1.82	1.89	1.88	1.94
122742	G8 V	4	0.00	0.18	0.34	0.45	0.54	0.61	1.22	1.28	1.26	1.30
124553	dF8	4	0.00	0.12	0.24	0.33	0.42	0.48	0.97	0.99	1.01	1.14
125184	G0	5	0.00	0.18	0.32	0.41	0.50	0.53	1.16	1.20	1.20	1.29
126053	dG3	6	0.00	0.13	0.25	0.33	0.41	0.48	0.98	0.98	0.98	1.08

H.D.	Sp.	n	4500	4400	4300	4200	4100	4000	3900	3800	3700	3600
128167	F2 V	4	0.00	0.06	0.10	0.16	0.21	0.25	0.54	0.63	0.86	0.99
130948	dG2 (SB)	4	0.00	0.11	0.22	0.31	0.37	0.42	0.90	0.93	0.96	1.07
133640	dG1, dG2	4	0.00	0.14	0.25	0.34	0.41	0.46	0.96	0.98	1.00	1.12
135102	G7	4	0.00	0.16	0.31	0.42	0.50	0.58	1.21	1.26	1.23	1.29
137107	G2 V	6	0.00	0.12	0.22	0.29	0.36	0.40	0.87	0.88	0.92	1.04
140573	K2 III	6	0.00	0.27	0.53	0.76	0.96	1.04	2.17	2.34	2.27	2.43
141004	G0 V	6	0.00	0.13	0.23	0.30	0.37	0.40	0.92	0.92	0.94	1.05
142373	F9 IV, V	4	0.00	0.12	0.24	0.32	0.40	0.45	0.86	0.88	0.96	1.11
142860	F6 IV (SB)	4	0.00	0.10	0.20	0.27	0.35	0.39	0.77	0.82	0.95	1.10
143761*	G0 V	9	0.00	0.13	0.24	0.32	0.40	0.46	0.96	0.98	1.02	1.14
144579*	G8 V	4	0.00	0.15	0.29	0.39	0.48	0.56	1.17	1.16	1.15	1.18
145328	K0 III (SB)	5	0.00	0.21	0.45	0.64	0.76	0.88	1.78	1.88	1.83	1.95
145675*	K0 IV	4	0.00	0.21	0.43	0.57	0.68	0.74	1.52	1.66	1.70	1.77
146233	dG1	4	0.00	0.15	0.27	0.37	0.46	0.52	1.10	1.12	1.11	1.21
150680AB	G0 IV	5	0.00	0.14	0.26	0.34	0.41	0.46	1.01	1.03	1.06	1.20
150997	G8 III, IV	4	0.00	0.20	0.39	0.53	0.63	0.69	1.47	1.51	1.48	1.62
152391	G8 V	5	0.00	0.17	0.33	0.45	0.56	0.65	1.28	1.32	1.30	1.39
152792	G0 V	16	0.00	0.13	0.24	0.31	0.38	0.45	0.93	0.91	0.94	1.06
154345	G8 V	5	0.00	0.17	0.32	0.43	0.50	0.57	1.24	1.26	1.24	1.30
156283	K3 II	4	0.00	0.28	0.62	0.99	1.26	1.44	2.72	2.78	2.72	2.81
157089	G0 V	7	0.00	0.10	0.18	0.27	0.34	0.40	0.80	0.81	0.86	0.99
157214	G0 V	7	0.00	0.13	0.23	0.30	0.37	0.43	0.92	0.91	0.91	1.04
157347	G5	4	0.00	0.15	0.27	0.36	0.46	0.53	1.12	1.14	1.10	1.18
158633*	K0 V (SB)	4	0.00	0.16	0.32	0.42	0.53	0.62	1.28	1.31	1.27	1.29
159222	G5 V	4	0.00	0.14	0.26	0.35	0.41	0.47	1.04	1.06	1.06	1.16
160269	G1 V	8	0.00	0.13	0.24	0.32	0.40	0.45	0.96	0.98	1.00	1.10
160346*	K2 V	5	0.00	0.25	0.46	0.62	0.78	0.91	1.74	1.87	1.87	1.87
160693	G0 V	4	0.00	0.11	0.22	0.28	0.36	0.42	0.85	0.84	0.86	0.95
161797	G5 IV	6	0.00	0.18	0.33	0.46	0.55	0.60	1.32	1.37	1.35	1.46
163588	K2 III	6	0.00	0.28	0.54	0.77	0.95	1.07	2.16	2.30	2.24	2.38

H.D.	Sp.	n	4500	4400	4300	4200	4100	4000	3900	3800	3700	3600
164922	K0 V	5	0.00	0.18	0.34	0.46	0.57	0.65	1.39	1.46	1.43	1.49
165401*	G0 V	5	0.00	0.13	0.24	0.32	0.39	0.43	0.91	0.93	0.92	0.98
173667	F6 V	4	0.00	0.08	0.14	0.21	0.28	0.34	0.71	0.75	0.88	1.03
178428	dG4 (SB)	4	0.00	0.17	0.31	0.41	0.49	0.54	1.18	1.21	1.22	1.30
179957/8	G4 V	7	0.00	0.15	0.27	0.35	0.43	0.50	1.08	1.07	1.07	1.15
182488*	K0 IV	4	0.00	0.20	0.37	0.50	0.58	0.63	1.41	1.46	1.44	1.49
182572	G8 IV	4	0.00	0.18	0.34	0.48	0.56	0.59	1.36	1.44	1.34	1.47
182807	F6 V	7	0.00	0.09	0.19	0.25	0.31	0.36	0.76	0.77	0.86	0.99
184499	G0 V	6	0.00	0.10	0.20	0.27	0.35	0.41	0.82	0.81	0.87	0.99
185144	K0 V	4	0.00	0.18	0.35	0.46	0.55	0.63	1.37	1.41	1.34	1.37
186408	G2 V	9	0.00	0.14	0.26	0.34	0.42	0.50	1.06	1.08	1.09	1.20
186427	G5 V	7	0.00	0.14	0.26	0.35	0.42	0.48	1.06	1.08	1.06	1.15
187923	G2 V	13	0.00	0.14	0.26	0.34	0.42	0.47	1.02	1.02	1.02	1.14
188512	G8 IV	6	0.00	0.19	0.36	0.49	0.57	0.61	1.36	1.44	1.37	1.47
190067	dG7	5	0.00	0.15	0.29	0.40	0.49	0.58	1.20	1.22	1.17	1.23
190360	G6 IV	5	0.00	0.18	0.34	0.46	0.55	0.59	1.36	1.38	1.34	1.40
193664	G5 V	5	0.00	0.12	0.22	0.31	0.38	0.44	0.95	0.98	0.98	1.07
196755	G5 IV	6	0.00	0.16	0.29	0.38	0.47	0.53	1.14	1.13	1.14	1.27
197076	dG2	5	0.00	0.13	0.25	0.32	0.40	0.46	0.99	0.99	0.98	1.07
197989	K0 III (SB)	4	0.00	0.22	0.45	0.64	0.78	0.90	1.82	1.88	1.86	1.94
199191	K0 III	4	0.00	0.19	0.34	0.54	0.67	0.79	1.58	1.57	1.56	1.67
201091	K5 V	5	0.00	0.25	0.51	0.76	1.02	1.30	2.26	2.28	2.26	2.25
201891	F9 VI	4	0.00	0.09	0.17	0.23	0.29	0.34	0.65	0.68	0.76	0.86
208110	G2 III	9	0.00	0.15	0.28	0.40	0.50	0.59	1.16	1.11	1.16	1.38
208776*	F8 V	4	0.00	0.11	0.22	0.31	0.38	0.43	0.90	0.93	0.96	1.07
210027	F5 V (SB)	10	0.00	0.08	0.15	0.21	0.26	0.32	0.67	0.73	0.89	1.05
211476	G2 V	4	0.00	0.10	0.20	0.27	0.34	0.40	0.88	0.88	0.91	1.01
215549	K1 III, IV	4	0.00	0.20	0.38	0.55	0.66	0.75	1.56	1.59	1.54	1.62
215812AB	G5 V	6	0.00	0.14	0.25	0.34	0.43	0.50	1.06	1.09	1.07	1.15
217014	G5 V	11	0.00	0.15	0.28	0.38	0.45	0.51	1.14	1.18	1.16	1.27
217166AB	dG1	5	0.00	0.14	0.26	0.34	0.42	0.47	1.04	1.07	1.05	1.16
219615	G8 III	4	0.00	0.19	0.37	0.53	0.65	0.72	1.51	1.50	1.49	1.59
224930AB	G2 V	13	0.00	0.14	0.25	0.34	0.41	0.48	0.97	0.96	1.05	1.15
225239	G2 V	6	0.00	0.13	0.24	0.33	0.40	0.45	0.92	0.97	1.00	1.11

TABLE II

Comparison of the intrinsic spectral energy distribution of the nucleus of M31 with a composite of H.D.109358 = β CVn (G0 V) and H.D.140573 = α Ser (K2 III). In the model one third of the light at 4500 A. is contributed by dwarfs.

λ	G0 V + K2 III	$(M31)_0$	Dwarf light
	m	m	per cent
4500	0.00	0.00	33
4400	0.21	0.20	37
4300	0.42	0.41	40
4200	0.58	0.61	43
4100	0.72	0.74	46
4000	0.79	0.80	47
3900	1.57	1.55	62
3800	1.63	1.62	65
3700	1.62	1.63	63
3600	1.77	1.76	65

TABLE III

Comparison of the intrinsic spectral energy distribution of the nucleus of M32 with a composite of H.D.109358 = β CVn (G0 V) and H.D.140573 = α Ser (K2 III). In the model one half of the light at 4500 A. is contributed by dwarfs.

λ	G0 V + K2 III	$(M32)_0$	Dwarf light
	m	m	per cent
4500	0.00	0.00	50
4400	0.19	0.17	54
4300	0.36	0.35	57
4200	0.50	0.52	60
4100	0.62	0.64	63
4000	0.69	0.73	64
3900	1.36	1.32	76
3800	1.40	1.37	79
3700	1.40	1.39	78
3600	1.52	1.58	78

point might contribute significantly to the integrated brightness of the nuclear region of M31. Table III shows that a dwarf enriched model, in which G0 V stars and K2 III stars contribute equally at 4500 A., gives a satisfactory representation of the spectral energy distribution of M32 over the range $3600 < \lambda < 4500$ A.

Inspection of individual tracings of M32 shows that the blue cyanogen bands in M32 are much weaker than they are in M31. This is in qualitative agreement with the data in Table II and III which show that giants contribute only 40 per cent of the light in the M32 model at λ4200, compared to 57 per cent in the M31 model. To account for the quantitative differences between the cyanogen band strengths in M31 and M32 it may be necessary to assume that some of the giants in the nucleus of M32 are metal-poor objects in which CN is weak.

Some of the tracings used in this investigation were obtained by Inge J. Sackmann, W. E. Greig and R. C. Henry. Thanks are also due to J. Peter Hagen, Jr. for providing MK classifications of a number of programme stars. Generous financial support was provided by the National Research Council, Ottawa.

References

Bergh, S. van den. 1963, *Astron. J.*, vol. 68, 413; 1966, "Spectral Classification and Multi-colour Photometry," I.A.U. Symposium No. 24. (Academic Press, London) p. 132; 1967, *Astron. J.*, vol. 72 (in press).

Bergh, S. van den and Henry, R. C. 1962, *D.D.O.Pub.*, vol. 2, 281, no. 10.

Bergh, S. van den and Sackmann, I. J. 1965, *Astron. J.*, vol. 70, 353.

Oke, J. B. 1960, *Ap. J.*, vol. 131, 358.

Whitford, A. E. 1958, *Astron. J.*, vol. 63, 201.

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VOLUME II NUMBER 19

A STUDY OF THE VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 14

II. PERIODS AND LIGHT CURVES OF THE SECOND GROUP OF TWENTY VARIABLES

HELEN SAWYER HOGG
AND
AMELIA WEHLAU

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A STUDY OF THE VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 14

II. Periods and Light Curves of the Second Group of Twenty Variables

By Helen Sawyer Hogg and Amelia Wehlau

The data forming the basis of this program, and its purpose, have already been described in the *Publications of the David Dunlap Observatory*, vol. II, no. 17, 1966. In the present paper we give the observations for the second group of twenty variables in Messier 14, NGC 6402, with their mean light curves. A summary of this material was presented to the American Astronomical Society (Sawyer Hogg and Wehlau, 1965). The cluster is now shown to contain four long-period Cepheids, which means that it is exceeded in the number of Cepheids, among globular clusters of our own Galaxy, only by Omega Centauri. Therefore we describe the period-luminosity relation it defines.

This second group consists of the following variables: numbers 3, 8, 12, 13, 14, 17, 18, 20, 27, 31, 34, 37, 51, 59, 61, 62, 68, 71, 75 and 76. Table I gives, for each of these variables, the maximum, minimum and mean magnitudes, the epoch of maximum (usually the nearest maximum just before J.D. 2438200 in the 1963 series of observations), and the period, followed by the value of Beta, and remarks, when pertinent. For several stars for which our observations do not completely rule out an alternate period, the date of maximum is that actually observed.

Of this group of 20 variables, only three are not RR Lyrae stars. One of these is a Cepheid, Variable 76, whose discovery was reported in our first paper. Its period now is calculated as 1.89003 days, and it raises to four the number of Cepheids in the cluster with periods determined.

The other two non-RR Lyrae stars, Variable 17 and Variable 27 are probably not members of the cluster. Variable 17 has a period of 12.097 days with an amplitude of only 0.65 magnitude, a sine-type light curve, and the largest period change so far found among our variables. Its value of Beta is $+35 \times 10^{-7}$ day/day. This variable is about two magnitudes brighter than the RR Lyrae stars. Its spectrum was investigated by Joy (1949) and found to vary between F8 and G2, and his measured radial velocities were +9 and −18 km/sec.

TABLE I

ELEMENTS OF TWENTY VARIABLES

Var.	Magnitudes Max.	Min.	Mean	Epoch of Maximum	Period days	Remarks
3	16.65	17.55	17.1	38199.823	0.522455	$\beta = -23$
8	17.8	18.6	18.2	38199.496	0.686071	R
12	17.1	18.6	17.85	38199.918	0.503952	R
13	17.0	18.6	17.8	38199.690	0.535215	$\beta = +41$
14	17.2	18.1	17.65	38199.931	0.471857	R
17	15.5	16.15	15.8	38204.72	12.097	R
18	16.9	18.15	17.55	38199.885	0.479065	$\beta = -23$
20	17.9	18.55	18.2	38198.734	0.263721	R
27	16.45	17.6	17.0	34936	167.0	R
31	16.8	17.7	17.25	38199.383	0.619636	R
34	17.8	18.8	18.3	38199.854	0.606627	$\beta = +13$
37	17.65	18.9	18.25	38199.654	0.489060	R
51	17.6	18.15	17.9	38198.709	0.367606	R
59	17.4	18.75	18.05	38199.561	0.555634	
61	16.6	17.7	17.15	38199.610	0.569824	R
62	18.0	18.5	18.25	38235.444	0.638460	R
68	17.1	18.7	17.9	38199.958	0.507217	R
71	17.05	18.3	17.7	38199.602	0.525925	
75	16.9	18.1	17.5	38199.737	0.545281	
76	16.15	16.9	16.55	38199.466	1.89003	R

REMARKS TO TABLE I

Var. 8 Large scatter.
Var. 12 Maximum seems low in 1940.
Var. 14 Large scatter.
Var. 17 Peculiar type of variable. $\beta = +35{,}000$. P $= 0^d.92131$, with $\beta = +210 \times 10^{-10}$ represents the observations nearly as well.
Var. 20 P $= 0^d.358181$ also fits data.
Var. 27 P $= 308^d.3$ almost as good for these observations.
Var. 31 Large scatter.
Var. 37 Difficult to measure, near cluster centre.
Var. 51 P $= 0^d.268795$ and $0^d.268597$ also represent observations.
Var. 61 Large scatter.
Var. 62 P $= 0^d.389254$ also fits observations.
Var. 68 Large scatter.
Var. 76 Short period Cepheid.

He compared these values with the cluster velocity of -131 km/sec earlier determined by Mayall (1946). Though Joy noted that his own velocity measures have some uncertainty because the spectral lines are few and poor, he questioned the cluster membership of the variable both because of the poor velocity agreement, and the distance of the star from the cluster centre. Further data are needed to assign a definite type of variability for this star.

Variable 27 has the second greatest distance from the cluster centre of all the 76 variables. It is a long-period variable, at maximum about one magnitude brighter than the RR Lyrae stars at maximum. A period of 167.0 days seems to represent our observations, but since the distribution of the plates is not favourable for the determination of such long periods, we cannot yet rule out a period of 308.3 days.

Seventeen of the variables are RR Lyrae type, with periods between 0.263721 and 0.686071 days. Four of these stars, Variables 3, 13, 18 and 34, show period changes. Of these changes, two are positive and two negative, with the values of Beta falling between +41 and −23. None of the RR Lyrae stars reported in our first paper showed period changes. For several of the RR Lyrae stars it proved difficult to decide among several related periods, as indicated in the table. In the case of Variable 62, we are greatly indebted to Dr. R. Margoni who generously supplied us with his unpublished measures from his Asiago plates to help in the period selection. Although it is tempting to draw a frequency distribution for the 34 RR Lyrae periods so far determined, this would not be meaningful until a higher proportion of periods have been found for the variable stars in this cluster.

TABLE II

CEPHEID VARIABLE STARS

Var.	Magnitudes Max.	Min.	Mean	Period days	Log P
1	14.65	16.1	15.35	18.73*	1.27
2	15.8	17.0	16.4	2.79468	0.45
7	15.4	16.5	15.95	13.596	1.13
76	16.15	16.9	16.55	1.89003	0.28

*Period changing.

Data for the period-luminosity relation as provided by the four Cepheids are tabulated in Table II; these are plotted in figure 1, along with the mean magnitudes of the 34 RR Lyrae variables. All the stars from our two papers are shown, except Variables 17 and 27, just discussed. Curiously, Variable 17 would lie close to the curve, but since it is probably not a cluster member, and perhaps not a

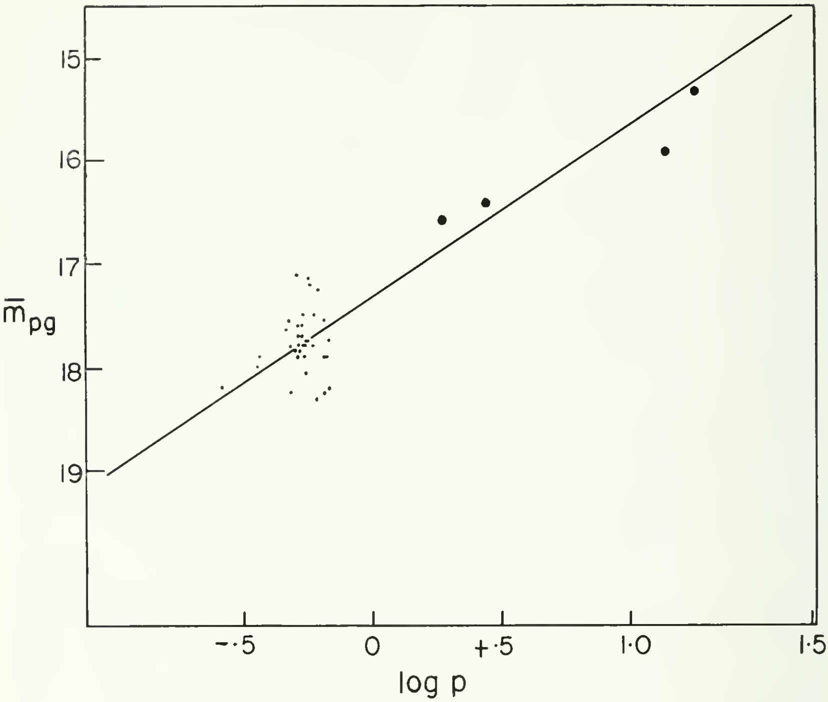

FIG. 1—The period-luminosity relationship as defined by variable stars in Messier 14. *Ordinate*, mean apparent photographic magnitude; *abscissa*, logarithm of the period. The large filled circles represent the four recognized long-period Cepheids; the small dots are the 31 RR Lyrae *ab* stars whose periods have thus far been determined.

Cepheid, it is not included. With a mean of the 31 RR Lyrae stars at 17.74 m_{pg} and log $P = -0.25$, the points indicate a slope of about -1.6, which compares with -1.74 obtained by Dickens and Carey (1967) in their paper discussing globular-cluster Cepheids. Some of the scatter in the magnitudes of the RR Lyrae stars is certainly real; part of it may be due to the effect of image crowding or to inclusion of field stars. Until the period determination of the variables in this cluster is more nearly complete, it cannot be known if more Cepheids are contained in it.

If we assume $M_{pg} = 0.6$ for the RR Lyrae stars in this cluster, from the average mean magnitude of the 31 RR Lyrae *ab* stars, the apparent photographic distance modulus is 17.1. Kron and Mayall (1960) give a visual absorption of 1.5 (Case I) or 1.8 (Case II). Correcting the

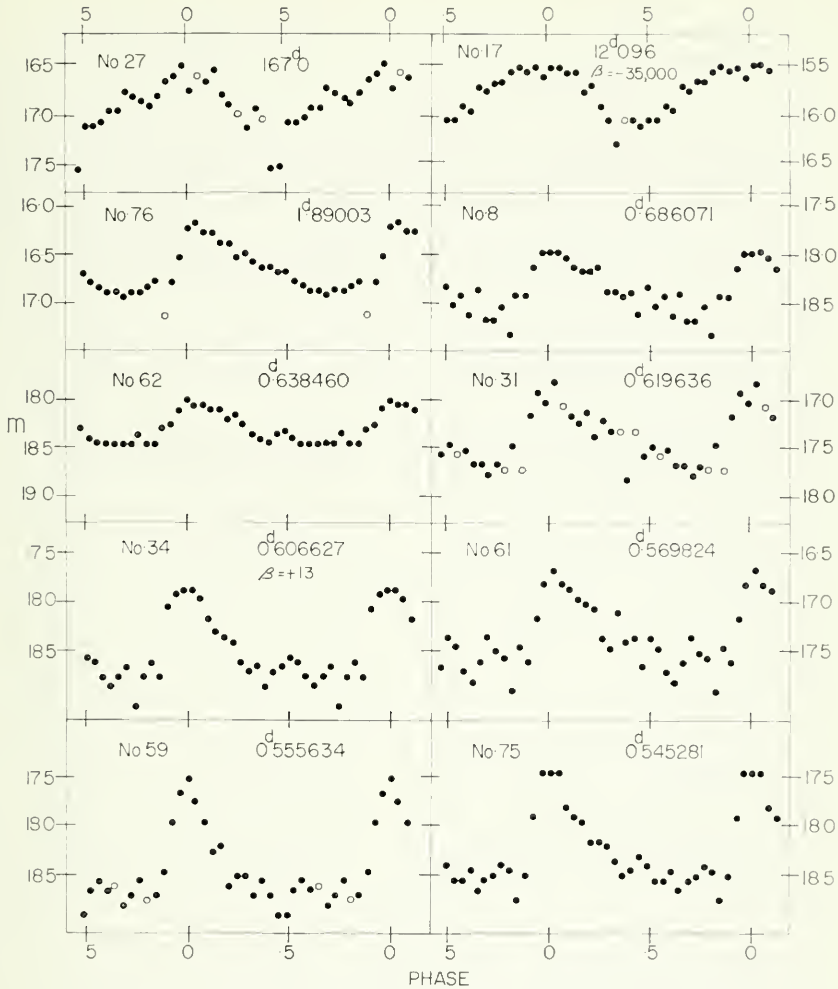

FIG. 2—The mean light curves for 10 variables, arranged in decreasing length of period.

photographic modulus by -0.6 to a visual modulus of 16.5 and accepting Case II, we obtain a corrected distance modulus of 14.7 corresponding to a distance of 8.5 kpc.

The light curves of these twenty variables, in order of decreasing length of period, are shown in figures 2 and 3. The points are the computed weighted means of all observations at intervals in phase of 0.04 of the period of the star. Observations with colons in Table III have

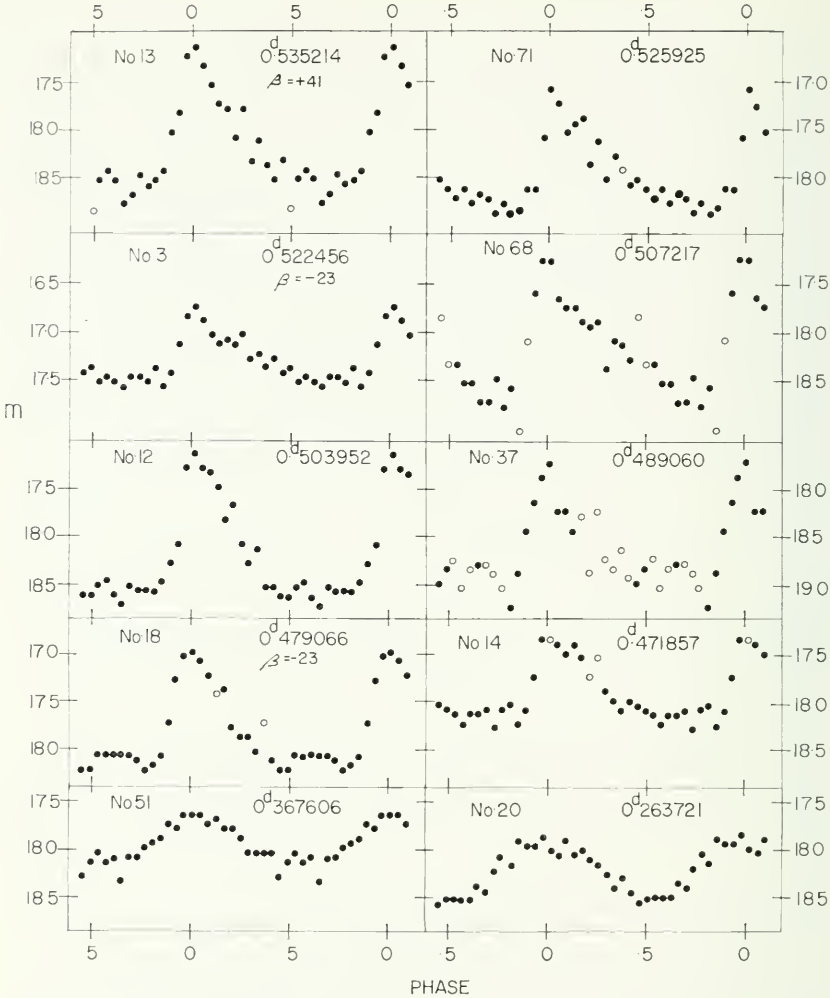

FIG. 3—The mean light curves of 10 variables, arranged in decreasing length of period.

been assigned half weight. A filled circle represents at least three good observations, but averages about ten such. Open circles represent mean points derived from observations which are few in number or of low weight.

The observations for these twenty variables are contained in Table III, which gives the number of the plate, the heliocentric Julian Day,

TABLE III

Observations of Variable Stars in NGC 6402

Plate	Julian Day*	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
103	2419536.939						15.75			16.5	
2637	20726.750	17.1	18.0		18.2	18.4	16.2		18.3	16.9	17.9
2649	48.705	17.2	17.7	17.9	18.5	18.1	15.55	17.1	18.4	16.55	17.05
4397	1690.895	17.35:	17.7:		18.5:	18.1	15.65			16.65	17.9:
20544	26915.824	17.4	18.4	18.65:	18.2	17.8	15.6	18.0:	18.6	16.2	16.9
20559	21.824	16.85	18.5	19.0:	18.8:	17.9	15.45	18.3	18.1	16.4	
20571	23.785	17.3:					15.35:			16.3	
20584	24.758	17.4			17.4:		15.25		18.2	16.2	
20587	.824						15.45	16.5:	18.6:	16.5:	
20597	25.776	17.9:			18.35:		15.4			16.15	
20647	44.781	18.05:	18.35		18.8:		15.95	18.2	18.1:	16.25	
20675	46.742		17.7:				15.55		18.0	16.4:	
21377	27272.781	17.2	18.3	17.15	18.2:		15.6:	17.3:	18.1	16.65	
21380	.864	17.65	18.7	17.85:	18.35:	17.9:	15.55	17.5	18.4	16.6	
21386	73.788	17.45	17.95	17.3	17.7	18.8	15.4	18.5	18.0	16.5	17.5:
21399	74.776	17.3	18.6	17.0	17.4	18.3	15.4	18.1	18.8	16.5	17.1
21406	.891	17.1:	18.8	17.9:	18.7:	17.7	15.7	17.7	17.6	16.55	17.1:
21412	75.768	17.2	18.8	17.0		18.6	15.65	18.0	18.6	16.45	16.9
21416	.856	17.6	18.2	17.8	17.4	18.8	15.55		18.6	16.45	16.85
21515	306.776	17.7:	17.45	18.3:	18.5:	17.8	15.8			17.2	16.4:
21538	07.799	18.1:	18.2:	18.5:	18.5:	17.8:	15.6		18.3	16.6	
21556	08.800						15.65:			17.2:	
23178	639.790	17.1	18.2	18.4:	17.7	17.3	16.0	18.15	18.8	17.0	18.2
23237	58.749	17.2	17.95	17.1	18.7	17.6	15.45	16.95	18.8	17.25	16.6
23240	.811	17.35	17.9	17.4	18.25	17.9	15.55	17.75	18.0	17.2	17.1

*Heliocentric

Plate	Julian Day	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
23252	27659.760	17.1	18.75	17.0	18.3	18.5	15.5	17.7	18.6	17.9	17.3
23255	.823	17.45	18.4	17.5	18.3:	18.4	15.55		18.2	17.55	
23256	.840		17.9	17.6:	18.1:	17.9:	15.65	18.4:	18.0	17.35	
23306	64.765	17.4:	18.55	18.35	18.7	16.85	16.1	18.25	18.7	17.25	17.75
23308	.802	16.8	18.4	17.35	18.6	17.3	16.05	18.7	18.7	17.5	17.4
23522	713.649	16.8:			17.0:		16.2:	17.5:	17.8		
23529	14.663	17.4	18.7	18.65	17.8	18.1	16.2	18.9	18.0	17.05	17.4
23538	15.661	16.7:	17.8:				16.0	18.5:	18.2:	16.8:	
23600	28.630	16.9:					16.0:				
91	8015.608	17.55	17.8	17.45	18.0	18.3	16.2	18.2	18.4	17.05	17.1:
92	.677					18.0	16.2:	16.8:	18.0:		
100	16.610	17.1		17.25	17.35	17.35:	16.05	17.6	18.2	16.95	17.4:
101	.628	17.4		17.65	17.8	17.7:	16.05	17.3	18.2	17.05	
102	.674						16.1	16.15:	18.0	17.0	
103	.693	17.45:					16.0	16.5:	18.0	16.9	
104	.711	17.35:		19.0:	17.55		16.2	16.6:	18.2	17.1	
105	.732						16.3:			17.15:	
169	37.599	17.4:	17.9:			17.2:	15.95	17.7:		16.8	
170	.617						15.75:			16.9:	
185	38.569	17.2	19.0:	18.45	17.5	17.5	15.65	18.4	18.1	16.7	17.1:
186	38.582	17.65	18.7	18.3	17.7	17.6		18.0	18.0	17.15	17.0:
187	.608	17.15:	18.6:		17.9:	17.1:	15.9	17.7:	17.9	16.5	
189	.644	17.3:			17.5:	17.0:	16.1:	17.6:	18.2	16.8	
192	.701						16.1:		18.2:	16.35	
217	43.571	16.9	18.8:		19.0:		15.8	17.6	18.1	16.7	
219	.610	16.8	17.7	19.0:	19.0:	18.3	15.7	17.55	17.8	16.65	16.9:
223	.677	16.8	17.75			16.9:	15.85	17.5:	17.8	16.45	
820	308.751						15.95:				
821	.769						15.9:				
824	.843						15.8:				

Plate	Julian Day	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
836	28309.767	16.8	17.65				15.8		18.0	17.4	
837	.781						15.7:		18.1:		
840	.835	16.8:	17.8:	17.65:	16.75:		15.65		18.4:	17.2	
1109	65.637	16.85:	17.75:		17.55:		16.2		18.0	17.0	
1110	.656	16.8:	18.8:				16.15		17.8	16.6	
1112	.706	17.3	18.15	19.0:	18.7:	17.9:	16.05	17.5	18.2	16.85	
1113	.723	17.5:			18.5:	17.5:	16.25	17.5:	18.7	17.05	
1115	.770	17.4:	18.05:		19.0:		16.15			17.1	
1123	66.631	17.15	18.0		17.25:		16.15		18.3:	16.85	
1124	.658	17.05	18.05		17.55		16.05		18.2	16.95	
1127	.729	17.35:	17.4:		18.2:		16.05		18.0	16.85	
1226	91.592		17.45:				16.1		>18.2	17.2	
1227	.613	16.75:	17.7:				15.85		18.6:	16.7	
1229	.678	16.9:	18.7:		17.8:		15.9		18.2:	16.65	
1230	.699	16.9:	19.5:				15.95			16.65	
1240	92.603	16.75	18.3	17.75	19.1	17.5:	15.9		18.0	16.75	16.85:
1241	.623	16.75	18.2:		18.5:	17.8:	15.95	17.8	18.1	17.0	17.4:
1244	.695	17.0	18.4	17.8:	19.0	17.7	15.8	17.1	>18.2	16.6	
1257	93.623						15.8:				
1267	98.587	17.1	17.65	17.4:	18.3:	16.65:	15.75	16.95	17.8	16.4	
1268	.609	17.2:	19.0	17.05	17.8	17.3:	15.75	17.4:	18.0	16.55	
1271	.653	17.0:	17.5:		17.15:		15.75		18.1	16.55	
1272	.679	17.4:	19.0:		17.6	17.7:	15.9:	18.1	18.2	16.85	17.9:
1284	99.582	17.25	18.9	17.15	19.1	17.35	15.85	18.3	18.1	16.9	17.3:
1287	.630	17.5	18.3	17.25	18.1	17.9:	15.95	17.8	18.0	16.4	
1290	.695		17.5:				16.0:			16.45	
1980	688.713	17.4:	18.4:		17.7:		15.95	18.3	18.0	16.95	
1982	.759	16.85:	17.8:		17.7:		15.95	17.1:	18.2	17.0	
1984	.822	17.55	18.5	17.1	18.5		16.0	17.2:	18.4		
1994	89.720	17.5	18.35	18.6:	18.15	17.2	16.15	17.4	18.2	16.9	17.1:

Plate	Julian Day	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
1997	28689.804	17.4	19.0	18.1	17.25	18.3	16.1	17.55	18.2	16.95	17.4:
2013	93.746	17.5:	17.4:				16.15	17.7:	17.7:	16.7	
2021	95.759	17.2	18.5	19.5:	17.35:		15.7		18.0:	17.05	
2033	96.679	17.05:	17.9:		17.7:		15.65			16.65	
2035	.722	16.95	17.8	19.0	17.6	17.3	15.55	17.7:	18.6	16.85	
2037	.776	17.3	17.8	18.4:	17.35	17.1	15.5	17.8	18.6	17.0	17.15:
2111	715.675	17.25:	18.2:	17.9:	17.25:	17.1:	16.2	17.1:	18.4	16.65	
2114	.747	17.1	19.5:	19.0:	18.2	17.4:	16.1	17.9	18.6	16.55	
2115	.770	17.55	19.5:	18.45	18.8:	18.3:	16.2	17.8	18.6	16.65	
3249	9071.710	17.25	18.7	17.85	18.15	17.95:	15.25	17.8	18.2	16.2	17.3:
3252	.798	17.3	18.75	18.05	18.1	18.7:	15.5:	18.1	18.2	16.55	17.3:
3263	72.780	17.65	18.15	18.35	18.3	18.0	15.6	18.4	18.3	16.5	16.5
3275	73.709	17.65	18.65	18.25	17.85	18.5	15.7	17.7	18.1	16.5	17.7:
3278	.783	17.55	18.25	18.15	18.25	17.2	15.8	18.0	17.8	16.55	17.3:
3290	76.742	17.65	18.5	19.0:	17.3:	17.8:	16.35		18.4	16.75	
3303	77.702	17.05	18.7	18.8:	18.9	17.9:	16.1	17.5:	17.7	16.55	
3318	78.722	17.25	18.45	18.35	18.6	17.6:	15.9	17.8	18.0	16.4	
4209	405.920						16.0:				
4228	06.956	17.2:	18.05:	17.8:	17.5:						
4584	30.738	17.1	19.0:	17.95	18.05	18.1	15.55	17.9:	18.2	16.65	17.7
4684	62.653	16.65		18.3	17.55		16.6	17.2:	18.2	16.6	
4693	63.648	17.35		18.8	18.2	17.6:		18.1	18.4		17.6:
4703	64.653	17.15	18.5:	18.6:	19.0:	17.9:	16.05	18.8:	18.3	16.7	17.6:
4795	87.614	17.1:	18.6:	16.5:			16.0	17.5:	18.2:	17.4:	
4807	89.702	17.5	19.5:	17.9:	18.2:	18.0	15.85	18.1	18.6	16.65	
4819	90.657	17.35	17.85	17.45	18.2	18.1	15.6	18.0	17.9	17.1	17.7:
4973	519.568	17.25	18.1	18.7	18.6	18.1:	15.55	17.2	18.3	17.2	
5702	785.764	17.35	17.95	18.2	17.75:	17.6:	15.8	18.0	18.0	16.95	17.8:
5717	86.812		18.3		19.0:		15.9		17.9:	16.95	
5728	87.784	17.15	18.15	18.8	18.5	17.8	16.05	17.15	18.3	16.65	16.6

Plate	Julian Day	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
5729	29787.810	17.1	18.9	19.5:	18.5	17.7:	16.05	17.2	18.9	16.6	17.1:
5808	813.677	17.75	18.3	17.4	17.6	17.3	16.05	17.0	18.3	16.9	17.5
5812	.784	16.95	18.7	18.6	17.85	17.8	16.1	17.7:	18.2	16.85	17.4:
5820	14.672	17.5	19.0	17.2	18.5	17.9:	15.85	17.4	18.3	16.8	17.8:
5825	.770	17.3	18.4	17.9	16.8		15.9	18.4	17.8	16.9	17.4:
5835	15.657		18.4:				15.9:				
5836	.711	17.85	18.2	18.05	19.1	18.0:	15.8	18.0	18.5	16.8	
5840	16.631	17.35	18.4	18.7	18.7	17.8:	15.6	17.9	18.0	16.9	17.6:
5843	.690	17.55	18.5	17.4	18.5	18.0	15.6	18.3	18.0	16.75	17.5:
5846	.733	17.6	18.7	17.85	18.5	18.0	15.55	18.4	18.4	16.85	17.8:
5848	.780	17.95	18.45	18.2	18.45	18.3:	15.6	18.4	18.4	16.9	18.3:
5948	41.688	17.4	17.95		18.1	17.6:	15.5	18.3:	18.2	17.05	
5964	42.703	17.0:	18.5:		18.0:		15.5		17.9:	16.8	
5974	43.623	16.85	19.0	18.7	17.7	18.4:	15.5	18.3	18.2	17.0	17.1:
5980	.732	17.4	19.5:	18.6:	17.8:		15.45		17.6	17.0	17.15:
6836	30169.693	16.8:	17.6:		17.4:	17.6:	15.5		17.8	17.3:	16.85:
6837	.722	17.2	17.6	19.0:	17.9	17.1:	15.55		18.0	17.9	
6838	.751	17.25	18.2	18.4	17.8	18.1:	15.5	17.7	18.2	17.7	
6839	.789	17.05	17.9	19.2:	18.5	17.5:	15.55	18.0	17.7	17.6	
6847	70.715	17.2	18.25	18.5	17.35	17.6:	15.55	17.8	18.1	17.6	17.5:
6861	71.730	17.2	18.3	18.45	16.9	17.65	15.35	18.15	18.4	16.95	17.55:
6864	.797	17.35	18.1	18.8	17.35	17.7	15.45	18.2	18.6	16.9	17.6:
6870	72.642	17.5	18.0	18.5	18.4		15.65		18.0	17.2	16.75
6875	.747	17.05	18.35	18.4	18.5	17.75	15.55	18.1	18.1	16.9	
6930	97.722						15.6:				
6938	99.705	17.25:	18.5:	17.0:	18.5:		16.1	17.7:		16.85	
6951	200.696						16.3:				
7923	549.662	17.4	18.9	18.65	18.0	17.9:	16.0		18.0	17.0	17.6:
7927	.750	17.3	19.5:	18.9:	18.1	17.6:	15.9		17.6	16.85	18.6:
7937	50.686	17.7	18.4	18.25	17.85	17.65	16.05	18.0	18.4	16.85	17.2

Plate	Julian Day	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
7940	30550.727	17.55	18.2	18.5	17.9	17.5	16.15	18.55	18.6	16.95	17.05
7943	.806	17.15	18.05	18.35	18.25	17.95:	16.05	18.1	17.6	16.6	17.0:
7949	52.679	17.75	18.05	18.15	18.3	17.4:	15.85	17.9	17.8	16.75	
7955	53.644	17.1	18.55	18.3	18.5	17.8	15.75	18.2	18.3	16.85	16.9
7961	.720	17.4	18.4	18.55	18.3	17.85:	15.65	18.35	17.6	16.75	17.05
7964	.779	17.3	18.05	18.8	17.4	18.1:	15.7	18.3	18.0	16.85	
7974	54.656	16.9	17.75	18.35	18.5	18.1	15.45	18.1	18.7	16.85	17.0:
7979	.739	17.1	18.05	18.45	18.5	17.8:	15.65	18.05	17.8	16.85	
8014	56.686	17.0	17.85	18.3	18.45	18.25:	15.45	17.8	18.0	16.9	18.0:
8020	.748	16.95	17.8	18.55	18.55	17.8	15.65	17.0	18.5	16.85	17.65:
8117	86.604	17.15	18.45	18.5	17.55	17.45	16.05	18.3	17.9	16.65	17.0
8895	899.685	17.05	17.9	16.9	18.25	18.1	15.85	18.1	18.2	16.9	16.95:
8902	.754	17.3	17.75	17.35	18.35	18.1	15.85	16.75	17.9	16.85	17.6
8907	.811	17.75	18.1	18.15	18.65	17.5	15.95	17.25	18.2	16.8	17.8:
8919	900.675	17.05	18.35	17.3	17.65	18.0	16.15	18.3	18.7	16.85	16.55
8926	.766	17.25	18.05	17.6	18.25	17.3	16.25	17.1	18.0	17.0	17.1:
8930	.813	17.4:	18.8	17.55:			16.0	17.2:	18.0	16.75	
9002	32.617	17.5	18.25	18.55	18.8	17.7:	15.5	18.7	18.2	16.8	17.35:
9003	.627	17.5	18.05	18.45	18.75	18.0:	15.5	17.7:	18.2	16.75	17.3:
9005	.652	17.55	18.05	18.55	18.9	17.55	15.5	17.8:	17.9	16.6	17.2:
9006	.661	17.6	18.2	18.4	18.75	18.1	15.55	18.3	18.0	16.65	18.05
9008	.685	17.65	18.15	18.75	18.7	18.5	15.55	18.2	17.8	16.7	17.8:
9009	.694	17.7	18.1	18.8	19.0	18.2	15.45	18.0	18.0	16.65	18.0
9011	.714	17.85	18.3	18.8	18.5	18.35	15.4	18.5	18.2	16.7	17.2:
9012	.724	17.75	18.2	18.45	18.2	18.0	15.4	18.5	18.2	16.65	17.8
9013	.734	17.5	18.3	18.65	17.95	17.8:	15.45	18.6	18.1	16.55	17.9
9022	33.600	17.45	18.2	18.2	18.75	18.0:	15.55	18.7	18.5	16.7	17.15
9023	.610	17.3	18.25	18.3	18.9	17.7:	15.55	18.3	18.7	16.7	17.0
9025	.635	17.5	18.7	18.75	19.0	18.1	15.6	18.05	18.6	16.75	17.0
9027	.658	17.55	18.3	18.6	18.4	18.1	15.55	17.9	18.4	16.65	16.85:

Plate	Julian Day	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
9030	30933.687	17.75	18.6	18.9	18.55	18.1:	15.5	18.3	18.0	16.85	17.1:
9033	.717	17.55	18.15	18.45	18.45	18.6:	15.6	18.4	17.8	16.7	17.05:
10134	1259.731	17.3	19.0:		17.65:	17.9:	15.55	17.65	17.8		
12045	969.756	17.4:	18.25:				15.65:		18.0:		
12051	.817	17.6	18.2		18.7:		15.55	18.2:	18.4:	16.95	
12070	70.779	17.5:	17.9:				15.7:				
12143	77.736	17.2	18.2	17.45	19.1:	18.2:	16.0	17.35	18.7	17.35	17.3
12260	99.693	17.3	18.7	18.45	18.3	17.9	16.15	17.8	18.2	17.8	16.9:
12345	2005.706	17.4	17.45	18.75	18.35	18.6	15.35	18.05	18.1	17.35	17.3:
12349	.758	17.4	18.15	18.45	17.45	18.6:	15.5	18.2	18.0	17.9	17.5:
12361	06.641	17.35	18.5	18.55	18.5	18.3	15.45	18.05	18.3	17.75	17.5:
12364	.677	17.3	18.4	18.5	18.5	18.5	15.55	18.1	18.6	17.85	17.85
12370	.747	17.35	18.45	18.7	18.55	18.7	15.45	18.5	18.5	17.75	17.2
13424	355.697	16.9	18.25	17.35	18.25		15.6	16.95	17.6	17.25	17.3:
13431	.756	17.45	18.2	18.15	17.9	18.3:	15.35	17.2	17.6	16.95	17.5:
13436	.828	17.75	18.7	18.7:	17.4:		15.45	17.3:	18.2	16.95	
13445	56.657	16.7	18.5	17.1	18.35	18.0	15.3	17.0	18.6	17.05	17.95:
13448	.710	17.05	18.75	17.55	18.75	18.4	15.6	17.05	18.5	16.95	17.7:
13460	57.655	16.65	18.15	17.15	18.45	18.5	15.75	16.85	18.1	17.1	17.55:
13464	.701	16.85	18.05		18.6	18.6	15.45	17.65:	18.9	17.2	17.8:
13488	60.659	18.1	18.9	16.95	17.05		15.85	17.75	18.4	17.0	17.15
13492	.723	17.3	18.45	17.55	17.55	17.05	15.85	18.4	18.0	17.15	18.1:
13497	.793	16.7	18.9	18.1	17.9	17.35:	15.85	17.95	18.1	16.9	
14580	740.637	16.85	18.2	17.1	17.3	17.5	15.45	18.5	18.3	16.8	17.35:
14584	.683	17.0	18.3	17.6	17.45	18.2:	15.6	18.05	18.4	16.9	17.6:
14591	.762	17.1	18.5	18.4	17.85	18.2	15.6	18.1	17.8	16.75	17.2:
14604	41.638	17.55	18.4	17.1	18.3	17.9	15.7	18.5	18.4	16.8	17.1
14609	.692	16.55	18.9	17.5	17.25	18.1:	15.6	17.9:	18.6	16.9	17.0:
14624	42.621	17.75	17.9	17.1	18.35	17.8	15.35	17.95	18.0	16.7	16.9:
14629	.673	17.55	18.3	17.45	18.55	18.4	15.6	18.15	18.2	17.05	

Plate	Julian Day	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
14638	32742.779	16.85	18.25	18.1	17.1	18.9	15.5	17.1	18.6	16.85	17.2
14756	70.616	17.55	17.85	18.45	17.35	18.5	16.05	17.0	18.2	17.15	18.0:
14764	.697	17.6	17.85	18.35	17.75	18.3:	15.85	17.85	18.5	16.95	18.3:
21395	4929.638	17.1	18.0	18.35	17.15		15.45	17.5:	17.8	16.6	
21402	.752	16.95	17.85	18.05	18.35	18.5:	15.4	17.7	18.2	16.55	17.6:
21426	31.665	17.4	18.6	18.8	18.55		15.7	17.6:	18.6	16.45	
21431	.719	17.1	17.75	18.8	16.85		15.8	16.6:	17.8	16.55	
22343	5273.697	17.05	19.1:	18.45	17.1	18.3:	16.2	17.4	18.6	16.8	17.5:
22348	.765	17.25	18.45	18.35	17.55	18.1	16.3	17.1	17.9	16.85	17.5:
22363	74.691	16.85	18.3	18.7	18.7		16.05	16.7:	18.4	16.9	
22371	.796	16.9	17.9:		16.9		16.05	17.5:	18.0	16.7	
22380	75.701	16.8		18.2	18.4	17.8:	16.05		18.1	16.9	
22385	.814	16.8	18.2	18.3	17.7:		15.95	17.6:	18.9		
22516	309.632	16.85	19.0	18.65	17.9	17.85:	16.55	17.35	18.1	17.0	17.3:
22521	.679	17.15	18.35	18.35	17.9	18.05	16.45	17.0	18.1	16.95	17.15
22540	10.624	16.7	17.7:	18.5	17.3	17.9:	16.2	16.85	18.5	16.95	17.1
23295	685.610	17.55	19.0:	18.4	18.55	18.1:	15.85	17.45:	18.3:	17.15	17.65:
23315	87.621	17.5	18.5	18.5	18.35	18.3:	15.6	17.4:	18.2	17.2	
23332	88.633	17.25	18.2	18.7	17.6	17.95:	15.4	17.2:	17.7	17.15	
23909	6044.661	17.25	18.6	18.05	18.5	17.5:	16.25	16.85:	18.0	17.1	16.9:
23913	44.697	16.75	18.45	17.65	18.2	17.6:	16.3	17.3:	18.1	16.95	
B1715	52.669	16.35:			17.5:		15.7:				
B1742	67.646	16.9:		18.1:			15.65:		18.0:	16.55:	
B1765	70.652	17.35:	18.0:		17.35:		16.1:			17.05:	
B1782	72.686	17.75:	17.75:		18.2:		15.8:		18.6:	16.95:	
B1789	73.640						15.6:				
24773	750.679	16.95	18.2	17.95	18.3	18.1:	15.9		17.9	16.85	
24779	.739	17.25	18.25	17.9	18.55		15.7	16.9	18.3	16.7	17.1:
24785	52.640	16.85	18.15	17.2	18.1	17.75:	15.45	17.05	18.4	16.75	17.25
24793	.733	17.05	18.25	17.95	18.2	17.75	15.55	17.35	17.8	16.9	17.6:

Plate	Julian Day	No. 3	No. 8	No. 12	No. 13	No. 14	No. 17	No. 18	No. 20	No. 27	No. 31
24808	36753.648	16.85	18.5	17.35	17.6	17.9:	15.6	16.75	18.4	16.85	17.35:
24813	.762	17.05	18.5	18.15	18.05	17.9	15.4	17.6	18.0	16.7	17.2:
26203	7849.648	17.15	18.25	17.7	16.9	18.4:	15.8	17.65:	18.3	17.35	17.8:
26204	.661	17.15	18.25	17.35	16.8	17.8:	15.9	17.8	18.3	17.9	17.6
26205	.682	17.4	18.0	16.95	16.95	17.8:	15.8	16.95	18.6	17.7	17.7:
26207	.707	17.4	18.2	16.8	17.05	18.0:	15.95	17.0	18.8	17.9	17.4:
26210	.750	17.0:	18.4	17.5	17.5	17.6	15.95	17.1	18.4	17.6	17.4:
26222	50.672	17.45	18.45	17.2	18.65	17.65:	15.6	16.7	18.2	17.65	17.4:
26225	.700	17.3	18.4	17.05	18.1	17.8:	15.55	16.95	18.2	17.5	16.9
26227	.733	16.95:	18.8	17.15	16.65	17.55:	15.65	17.25:	18.6	17.45	17.2
26829	8198.704	17.5	18.55	18.2	17.55		16.15	17.3:	17.8	17.1	
26835	.763	17.0	18.0	18.2	18.15		16.3	17.5	17.8	17.05	
26837	.783	16.85	18.4	18.45	18.9		16.25	18.35:	17.7	16.95	
26851	99.690	17.5	18.1	18.4	16.75	17.65:	16.05	17.9	18.8	17.05	
26853	.712	17.5	18.3	18.5	16.65	18.1:	15.8	17.6	18.3	17.1	17.7:
26857	.754	17.55	18.45	18.85	17.15	18.15:	16.0	17.65	17.8	17.1	17.95:
27559	587.693	17.45		18.8	17.1		15.55	17.45:	17.8	17.0	

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
103	2419536.939										16.8
2637	20726.750	18.6	18.9	18.0	18.4	17.8	18.6	19.0:	18.7	16.8	16.6
2649	48.705	17.9	18.7	17.85	18.3	18.3		17.8	18.4	17.7	16.9
4397	1690.895		16.8:			17.5		18.1:		17.05	16.8
20544	6915.824	18.5	18.8	18.15	19.0	18.3	18.4		18.3	17.8	16.7
20559	21.824	18.4			17.5	17.9	18.4	18.4	18.4	17.9	16.3
20571	23.785							18.7			16.2:
20587	24.824						18.1:		17.8:		16.8
20597	25.776						18.2:			17.5:	16.4
20647	44.781					17.7:		17.1:	18.2:	17.4:	16.8

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
20675	26946.742					16.6:					16.6:
21377	7272.784			17.5:		17.7:	18.2	18.7:	18.25:	19.0:	16.85
21380	.864	17.6		18.5:		17.1:	18.5	18.1:	19.0:	17.1	16.85
21386	73.788	18.7:	19.0:	17.75	18.7	17.4	18.2	18.4	18.1	18.1	16.6
21399	74.776	18.4	19.5:	18.45	17.9	17.7	18.8	19.5:	18.7	18.3	16.7
21406	.891	19.0		17.7	18.8:	17.3	>18.1	17.8	18.5:	17.7	17.1
21412	75.768	18.6	19.0:	18.2	18.7:	17.4	18.5	18.8	18.7	18.0	16.55
21416	.856	18.0		18.45	17.7:	17.2	18.6	18.8	18.05	18.2	16.8
21515	306.776	17.5:			18.0:	18.0		18.0	18.3:	17.2	17.1
21538	07.799	18.5:	17.3	18.0				17.4:	18.1:	17.0	16.45
21556	08.800										17.3:
23178	639.790	18.7		18.25	17.8	17.8	18.4	18.2	18.45	17.9	16.6
23237	58.749	18.05	18.7	17.75	17.9	18.3	18.1	18.4	18.8	18.2	16.25
23240	.811	18.1:		18.25	18.2	18.0	18.3	18.5	18.7	18.0	16.2
23252	59.760	18.9	18.9	17.8	17.55	17.7	18.6	18.7	18.25	18.3	16.9
23255	.823	18.0		17.7:	18.0	17.4	18.4	18.4	17.85:	18.2	16.85
23256	.840	18.0		17.6:			18.2		17.9:		17.0
23306	64.765	17.85	18.35	18.4	17.3	17.0	18.6	18.4	18.65	17.95	16.4
23308	.802	18.5	17.4	18.1	17.6	17.0:	18.4	18.1	17.4	18.0	16.4
23522	713.649									17.4:	16.3
23529	14.663		18.1	18.0	19.0:	17.9	18.6	18.9	18.8	17.7	16.85
23538	15.661	17.8:	17.5					17.5:	19.0:	16.7:	15.95
23600	28.630									17.7:	16.5
91	8015.608	18.6	18.7	18.0	19.0	17.35	18.1	17.8	17.25	17.2	16.75
92	.677	18.1:			18.2:	17.8	18.2	17.0		17.5	16.5:
100	16.610	18.1			18.4:	16.8:	18.4	17.6		16.7	16.45
101	.628	18.3	18.6:		18.2:	16.7:	18.4		17.2:	17.15	16.5
102	.674						18.3:				16.3:
103	.693						>18.1				16.5:
104	.711			18.3:		16.4:				16.55:	16.5

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
105	28016.732										16.5:
169	37.599				17.2	16.6:	>18.1	17.4:		17.3	16.6
170	.617										17.1:
185	38.569	18.7	19.0:	17.8	18.9	17.0	18.1	18.5	18.55	17.5	16.7
186	.582	18.4	18.2:	17.6		16.6		18.2		17.3	16.5
187	.608	19.5:			17.8:	16.5	18.1	17.3:		17.0:	16.25
189	.644				17.6:	16.4	>18.1	17.0:		17.6	16.2
192	.701					16.4:	18.0:				15.9
217	43.571	18.8	18.5:	17.9	18.1:	17.2	18.5:		18.6:	17.6	16.85
219	.610	18.1:	18.4:	17.7	18.4	16.8	18.3	18.4	17.7	17.8	16.8
223	.677	18.2:				16.35:	18.0	17.1:		17.7	16.9
836	309.767	18.7:		17.6:		16.1:		16.7:		17.4:	16.5
837	.781					16.1:	>18.1	16.4:			16.65
840	.835					16.2:					16.6
1109	65.637	19.0:					>18.1			16.5:	16.1
1110	.656					16.25:	>18.1				16.1
1112	.706			18.8:		16.75	18.5	17.8:	17.75:	17.4	16.1
1113	.723					16.6		17.0:	18.1:	17.1	16.1
1115	.770					16.4:	>18.1		18.5:	17.1:	16.2
1123	66.631		17.6:			17.3		17.6:		18.5	17.0
1124	.658	17.4:		18.05		17.2:	18.1:	17.4:		17.4	16.7
1127	.729					16.2:	>18.1			16.9	17.0
1226	91.592						18.2			17.7:	17.0
1227	.613					16.5:	>18.1		17.65:	17.0:	16.7
1229	.678						>18.1			17.3:	16.6
1230	.699										17.1
1240	92.603	18.2	17.6:	18.0	17.5	16.7:	18.1	17.5	17.85:	17.5	16.5
1241	.623	17.8	17.8:	17.6	17.2	16.8:	>18.1	17.6		17.6	16.55
1244	.695	18.4:	18.6:	17.9:	17.8	16.8:		17.5	17.4:	17.9	16.4
1267	98.587					16.7:		17.3:		17.4:	16.7

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
1268	28398.609			17.75:		16.8:	18.1	17.1:		17.4:	16.55
1271	.653					16.0:	18.1:				16.5
1272	.679	17.9		17.8:		16.35	17.9	17.7:	18.1:	17.9	16.55
1284	99.582	18.8	18.8:	18.45	18.4	16.9	18.4	17.4:	17.5	17.4	16.45
1287	.630			17.95	18.5	17.2	18.1	17.8:	17.5	17.5	16.35
1290	.695					16.7:					16.7:
1980	688.713	17.7:		17.8:	17.6:	16.3:				17.5:	16.6
1982	.759	17.6:		18.3:	17.3	16.45	18.5	17.5:	17.4	17.7:	16.4
1984	.822			17.9:	18.4:	17.0	18.1	17.6:		17.5:	16.2
1994	89.720	18.3	18.3:	18.35	18.6	18.3	18.6	17.7	18.7	17.8	16.8
1997	.804	19.0		17.6	19.0	17.0	18.2	18.2	17.45	18.3	17.0
2013	93.746				17.5:	16.6:				17.5:	16.8
2021	95.759		17.5:	17.6		16.9:		16.7:		17.2:	16.8
2033	96.679									17.1:	16.3
2035	.722	18.5:	16.9:	17.8:		16.5	18.5	16.5	18.1	17.4	16.35
2037	.776	18.1	17.9	17.5	18.3	16.9	18.5	17.15:	17.95	17.9	16.4
2111	715.675	18.2	18.4:		18.4:	16.4:	18.6	17.25		16.7	16.3
2114	.747		18.9:	18.1:	18.3:	17.4	18.5	18.4:	18.35	17.2	16.65
2115	.770	19.0:		18.1:		17.3	18.5	17.7:	17.85:	17.7	16.5
3249	29071.710	18.7		18.05	18.7	17.0	18.2	17.9	17.35	17.2	
3252	.798	18.7		17.75	18.7	17.05:	18.1	18.1	18.05	17.45	16.8
3263	72.780	18.6	18.5	18.0	17.9	17.3	18.4	18.5	17.8	18.1	16.4
3275	73.709	18.5		17.7	18.7	17.2:	18.3	18.0	17.7	18.1	16.7
3278	.783	18.1:	17.8	18.2	18.5:	17.75	18.5	17.7	17.45:	18.4	16.8
3290	76.742	19.5:		18.8		16.15:	18.2		18.0	17.1:	16.65
3303	77.702	19.0		17.85	17.7:	16.5:	18.3		17.6:	17.5:	16.75
3318	78.722	17.9		17.7	18.5	17.05	18.2	17.3:	17.85	17.6	16.5
4209	405.920										16.6:
4228	06.956										16.0:
4584	30.738	18.5	18.7:	18.5	18.6	17.3	18.4	17.9	18.4	18.3	16.5

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
4684	29462.653			17.7:		16.4:			17.85	17.8:	16.65
4693	63.648			17.8	18.6	16.45	18.3	16.8	18.1	18.0	16.35
4703	64.653	18.8		18.7:		17.0	18.5	16.8	18.1	18.2	16.8
4795	87.614					15.95:	>18.1				16.7
4807	89.702	18.5:		17.9	19.0	17.9		17.7	18.0:	17.9	16.8
4819	90.657	17.75	18.5	18.05	17.85	17.55	18.2	18.0	18.25	17.5	16.5
4973	519.568	18.6		17.8	19.0	17.4	18.6	18.0	18.05	17.55	16.9
5702	785.764	18.5:		17.6	18.3:	17.8	>18.1	17.4		17.9	17.0
5717	86.812			17.6			17.9:		17.15:		16.7
5728	87.784	18.7	18.2	18.1	17.6	18.2	18.6	17.5	18.0	17.3	16.6
5729	.840	17.5	17.7	17.95	17.7	18.0	18.3	17.4	18.2	17.9	16.6
5808	813.677	18.9	18.9	18.0	19.0	17.5	18.5	17.7	18.1	18.4	16.45
5812	.784	18.5:	17.8	18.4	19.0	17.6	18.5	18.6	17.55	18.7:	16.35
5820	14.672	18.0		17.9	19.0	16.85	18.5	17.5	18.15	18.0	17.0
5825	.770	18.7		17.7	18.9	17.0	18.2	17.7	17.0		16.75
5835	15.657									17.4:	16.4
5836	.711	18.0	17.8	18.25	17.9:	17.2	18.5	17.25:	18.4	17.55	16.3
5840	16.634	18.1	18.4	17.75	18.9	17.3:	18.4	17.15:	18.55	16.8	16.8
5843	.690	18.4	17.7	18.25	18.4	18.6	18.0	17.6	18.35	17.45	17.0
5846	.733	19.0	18.05	18.5	17.35	17.6	18.0	17.95	18.7	17.55	16.8
5848	.780	18.3:	18.6:	18.05	17.8	17.6	18.0	18.3:	18.35	17.8	16.85
5948	41.688	18.9		17.95:	17.5:	16.9	17.9	17.3:	16.95	16.55	16.2
5964	42.703					16.8:			17.0:		16.55
5974	43.623	17.8	17.8:	18.4	19.0	17.3	18.3	17.8		18.4	16.15
5980	.732	17.7		18.1:	19.0:	16.35	18.1:	17.7	17.4	17.8:	16.15
6836	30169.693					16.8:	18.6:			17.6:	16.8
6837	.722	18.1:		18.1:	18.5:	16.9	18.4:	16.9	18.0	17.5:	16.6
6838	.751	18.3:	17.4:	17.9:	18.3:	17.3	18.0		17.4	17.7	16.9
6839	.789		17.7	18.0:	18.2:	16.7:	18.0	17.15	16.95	17.8	16.65
6847	70.715	18.4:	18.8:	17.9	17.8	17.3	18.3	17.05	17.9	18.2	16.1

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
6861	30171.730	18.6	17.9	17.95	17.8	18.3	18.0	17.7	18.4	17.5	16.9
6864	.797	18.05	18.05	18.2	17.85	17.9	18.3	17.7	18.5	17.95	17.1
6870	72.642	18.6:		18.3	18.2:		18.2	17.8:	17.55:	16.8	16.3
6875	.747	18.4	17.9:	17.55	18.4	17.6	18.2	17.4	18.05	17.55	16.35
6938	99.705			17.5:		17.1				17.6:	16.45
7923	549.662	18.8		17.9	18.2:	17.2	17.9		17.55	17.7	16.7
7927	.750	17.7		18.3	18.4:	16.5	17.9		17.7	18.2	16.85
7937	50.686	18.65	19.0	17.75	18.1	17.75	18.2	18.3	17.6	17.9	16.15
7940	.727	18.7	18.0	17.8	17.8	17.7	18.4	18.4	17.8	18.0	16.4
7943	.806	18.7		18.65	18.4:	17.0:	18.6		17.65:	17.9	16.2
7949	52.679	18.6:		18.2	18.5:	16.7:	18.2	17.6:	17.1	17.4	16.3
7955	53.644	18.6:	18.35	17.65	18.4	18.0	18.2	17.55	18.25	18.05	16.9
7961	.720	18.8	18.2	18.05	18.6	16.9	18.4	18.2	17.15	18.3	16.8
7964	.779	18.6	17.9:	18.2	18.9	17.0	18.4		17.25	17.3	17.15
7974	54.656	17.85	17.9	18.1	17.9	17.55	18.6	17.4	18.25	18.25	16.3
7979	.739	18.2		17.45	18.6:		18.0		17.65:	18.2	16.3
8014	56.686	18.6	19.0:	18.0	18.8	17.05	18.0	17.95:	17.9	18.0	16.35
8020	.748	18.9		18.1	18.45	17.0:	17.9	18.05	18.15:	18.2	16.3
8117	86.604	18.6	18.5	18.15	18.8	17.6	18.2	17.5	17.95	17.5	16.35
8895	899.685	18.5	18.8:	18.05	17.3	17.1	18.0	18.15	18.25	18.0	16.9
8902	.754	18.1	19.0:	18.15	18.1	17.4	18.5	19.0	17.25	18.0	16.9
8907	.811	17.75	19.0:	17.9	18.8	17.6	18.6	18.7	17.55	17.8	16.7
8919	900.675	19.0	18.6	17.7	19.0	17.75	18.6	17.3	18.4	16.95	16.35
8926	.766	19.0:	18.4:	17.9	17.4	16.8	18.2	18.4	17.7	17.45	16.5
8930	.813					16.3	18.0		16.6	17.5:	16.6
9002	32.617	18.1	18.9	17.6	18.7	17.15	18.4	17.75	18.0	18.1	16.35
9003	.627	18.1	18.9:	17.75	18.5	16.8	18.6	17.7	18.3	18.0	16.4
9005	.652	18.7:	18.8	17.65	18.5	16.6	18.2	17.65	18.2	18.0	16.3
9006	.661	18.15	18.6	17.45	18.4	16.8	18.2	17.9	18.1	18.1	16.5
9008	.685	18.35	17.9	17.65	19.0	17.0	18.2	18.4	18.1	18.5	16.3

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
9009	30932.694	18.3	17.4	17.65	18.9	16.95	18.0	18.3	17.95	18.0	16.25
9011	.714	18.5	18.0	17.9	19.0	16.9	18.0	18.9	18.6	18.5	16.35
9012	.724	18.5	17.9	17.85	18.4	17.25	17.8	17.85:	18.3	18.25	16.45
9013	.734	18.4	17.9	18.0	18.7	17.1	18.0	17.75:	18.1	18.1	16.45
9022	33.600	19.0	19.2:	18.15	18.2	17.7	18.4	18.0	17.8	18.1	16.9
9023	.610	19.5	19.5:	18.1	18.2	17.3	18.5	18.1	17.65	17.95	16.85
9025	.635	18.7:	19.0:	18.45	18.35	17.4	18.4	17.75	18.1	18.2	16.85
9027	.658	18.55	18.3	18.15	18.3	17.75	18.3	18.3	17.9	18.3	16.75
9030	.687	18.7	18.2:	17.8	18.6	17.35	18.4	18.1	17.85:	18.1	16.9
9033	.717	18.6:	18.7	17.6	18.9	17.45	18.6	18.3	17.95	18.5	16.85
10134	1259.731	18.4:	18.3:	17.4	17.6	16.7:		17.1	18.9:	17.7	16.35
12045	969.756			17.15:			18.1:				16.6
12051	.817	17.7		17.5:	17.5	16.8:	18.2:	16.65	18.5:	17.7	16.4
12070	70.779										17.1:
12143	77.736	17.6	19.5:	17.4:	18.6:	17.2	18.5	19.0	18.55	18.2	16.4
12260	99.693	18.2:	18.6:	17.75	19.0	17.9	17.9	18.2	17.8	18.0	16.75
12345	2005.706	18.0	18.25	17.75	18.6	17.05	18.6	19.0	18.35	18.4	16.45
12349	.758	18.2	18.6	17.95	19.0	17.8	18.6	19.0	18.4	18.1	16.35
12361	06.641	19.0	18.3	18.1	18.3	18.1	18.0	18.9	18.45	18.2	16.7
12364	.677	18.8	18.2	18.05	18.8	18.4	18.0	19.0	18.65	18.1	16.8
12370	.747	19.0	18.9	17.65	19.0	17.25	18.2	19.0	18.55	18.35	16.7
13424	355.697	17.9		17.4	18.3:	17.1:	18.4	18.5:	17.7	17.85	16.3
13431	.756	18.4		17.85	18.6	17.5	18.3	18.7:	17.85	18.15	16.35
13436	.828	18.7:		17.8:			18.2		18.7:	18.8:	16.35
13445	56.657	18.7	19.0:	17.95	18.7	17.0	18.1	18.8	17.2	18.05	16.75
13448	.710	18.9	19.2	17.5	18.8	17.65:	18.3	18.9	17.55	18.2	16.95
13460	57.655	18.7		18.15	18.4	17.65	18.6	19.0:	16.95	17.4	16.25
13464	.701	18.7		18.35	18.4	17.75	18.3		17.3	18.1	16.15
13488	60.659	18.4:	19.0	18.0	19.0	16.9	18.5	18.6:	18.6	17.7:	16.9
13492	.723	18.6	18.3	17.6	18.9	17.2	18.5	18.9	18.65	18.0	17.0

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
13497	32360.793	19.0		17.5	19.0	17.15	18.5		16.9	18.3	16.6
14580	740.637	18.8	19.0:	17.8	18.8	17.9	18.4	19.0:	17.45	18.0	16.7
14584	.683	18.7:	19.5:	18.05	18.9	17.3	18.4	19.0	17.7	18.5	16.7
14591	.762	18.9	18.6	17.95	18.7	16.9	18.3	17.65	18.0	18.4	16.65
14604	41.638	18.4	19.0	17.45	18.3	17.85	18.2	19.2:	17.1	18.0	16.5
14609	.692	19.0		17.65	18.9	17.4:	18.4		17.25	18.4	16.7
14624	42.621	18.6:		18.05	18.9	17.6	18.6	19.0:	17.55	17.4	16.7
14629	.673	17.9	18.4	17.65	17.65	18.1	18.6	19.5:	17.05	17.65	16.7
14638	.779	18.5:	18.9	17.8	18.4	18.0	18.1	18.7	17.8	18.3	16.6
14756	70.616	18.1		17.7	18.5:	17.9:	18.3		17.3	18.3	16.85
14764	.697	18.9	19.0:	17.25	18.7:	17.55:	18.4	17.95	17.65	18.3	16.95
21395	4929.638	19.0:		17.55			18.0		17.75:		16.4
21402	.752	18.8		18.25	18.4:	17.55	18.4		17.65:	17.3	16.1
21426	31.665			18.05		16.6:	18.4		17.6	18.0:	16.25
21431	.719			17.75			18.2		17.4:		16.25
22343	5273.697	19.0:	19.0:	17.3	18.4:	17.0	18.2		18.1	17.8	16.2
22348	.765	19.0		17.7	18.4:	17.15	18.1		17.9	17.2	16.05
22363	74.691	18.4		17.7			18.5		18.2	18.2	16.65
22371	.796			17.7:	17.6:	16.9:	18.5		18.5:	18.0:	17.0
22380	75.701	18.7		17.95	18.3:	17.2	18.0	18.2:	17.95	17.8	16.15
22385	.814	18.0:		17.4:		16.85:	18.1			18.2:	16.25
22516	309.632	18.7	19.0	17.85	18.9	17.35	18.3	18.5	17.65	17.9	16.2
22521	.679	18.7	19.0:	17.4	18.25	17.7	18.4	18.6	16.95	18.1	16.1
22540	10.624	18.4		18.0	18.6:	16.95	18.1	18.3:	18.35	17.95	16.75
23295	685.610	19.0		17.6	18.8	16.7	18.4:		18.2	17.9	16.8
23315	87.621	19.0		17.6	18.4	17.3:	18.2		17.9	17.1	16.2
23332	88.633	18.7:		18.25	18.2:	17.5:	17.8		17.75	18.05:	16.7
23909	6044.661	18.6		18.05	18.15:	17.05	18.3	18.0:	18.15:	17.9	16.7
23913	.697	18.6:		17.55	17.9:	17.2	18.2	17.6:	17.45:	17.8:	16.9
B1705	51.660										16.9:

Plate	Julian Day	No. 34	No. 37	No. 51	No. 59	No. 61	No. 62	No. 68	No. 71	No. 75	No. 76
B1715	36052.669										16.6:
B1742	67.646			18.1:		17.4:					16.1:
B1752	68.663										17.5:
B1765	70.652			17.25:							17.3:
B1782	72.686			17.75:		17.6:		16.5:	17.95:		16.5:
B1789	73.640										16.6:
24773	750.679			17.45	18.3:	16.7:	18.2		16.9	18.1:	16.6
24779	.739			17.5	18.4:	17.4	18.5		17.25	18.7	16.7
24785	52.640	18.9		17.65	18.6	17.6	18.4		17.9	17.6:	16.8
24793	.733	18.9	19.0:	17.95	18.25	18.2	18.4	18.8	17.8	18.15	16.75
24808	53.648	18.05	19.0:	17.4	18.8	17.85	18.1	18.8	17.9	17.1	16.2
24813	.762	18.35	19.0:	18.1	18.5	17.55	18.4	18.4:	18.05	17.55	16.15
26203	7849.648	19.5:	19.0:	18.1	18.9	18.2	18.4	18.8:	18.15	17.3	16.95
26204	.661	18.9		18.0	18.4:	17.45	18.3	18.6	18.7	16.9	16.8
26205	.682	19.0		17.7		17.6	18.5	18.2:		16.9	16.9
26207	.707	19.0:		18.1	18.7	17.65	18.4	18.7:	18.3	17.5	17.0
26210	.750	18.6		17.95	19.0	17.05	18.1	17.9:	18.15:	17.7	16.8
26222	50.672			17.8	18.1	18.1	18.2	18.3:	18.35	17.9	16.55
26225	.700	19.0:		18.1	18.4	17.7	18.5	18.4	18.3	18.1	16.65
26227	.733			17.65	17.9:	17.55	18.5		17.85	17.35	16.6
26829	8198.704	18.1:		17.55			18.2		17.4	17.3	16.6
26835	.763			17.6		17.4:	18.6		17.95	17.9	16.8
26837	.783	18.1:		17.55		17.4:	18.3		18.1	17.7:	16.9
26851	99.690			18.6		17.3	18.0		17.8	17.65	16.25
26853	.712	18.7		18.05	18.3	17.2	18.0		17.6	17.3	16.1
26857	.754	19.1		17.65	18.9	17.75	18.2		17.8	17.3	16.25
27559	587.693	18.8:		17.7		17.2	18.5:		17.85:	17.95:	16.6

and the magnitude from the photometer reading. Some of these stars in the second group are substantially fainter than any in Paper I. This means that measures for them on many of the early plates, both of the Dominion Astrophysical Observatory and of the David Dunlap Observatory until the mirror was aluminized before the 1942 season, give uncertain results because the variable is close to the limiting magnitude of the plate. We found that in such cases the eye estimates made by one of us (H.S.H.) were as reliable as the photometer measures made by the other (A.W.) and resulted in less scatter in the light curve. Accordingly, for the two variables for which the effect was most noticeable, Variables 20 and 62, the published measures are usually means of photometer and eye estimates.

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References

Dickens, R. J. and Carey, J. V. 1967, *Roy. Obs. Bull.*, no. 129, p. E 335.
Joy, A. H. 1949, *Ap. J.*, vol. 110, p. 105; *Mt. W. and Pal. Repr.*, no. 5.
Kron, G. E. and Mayall, N. U. 1960, *A.J.*, vol. 65, no. 10, p. 581.
Mayall, N. U. 1946, *Ap. J.*, vol. 104, p. 290; *Lick Cont.*, Ser. 2, no. 15.
Sawyer Hogg, H. and Wehlau, A. 1965, *A.J.*, vol. 70, no. 9, p. 678.